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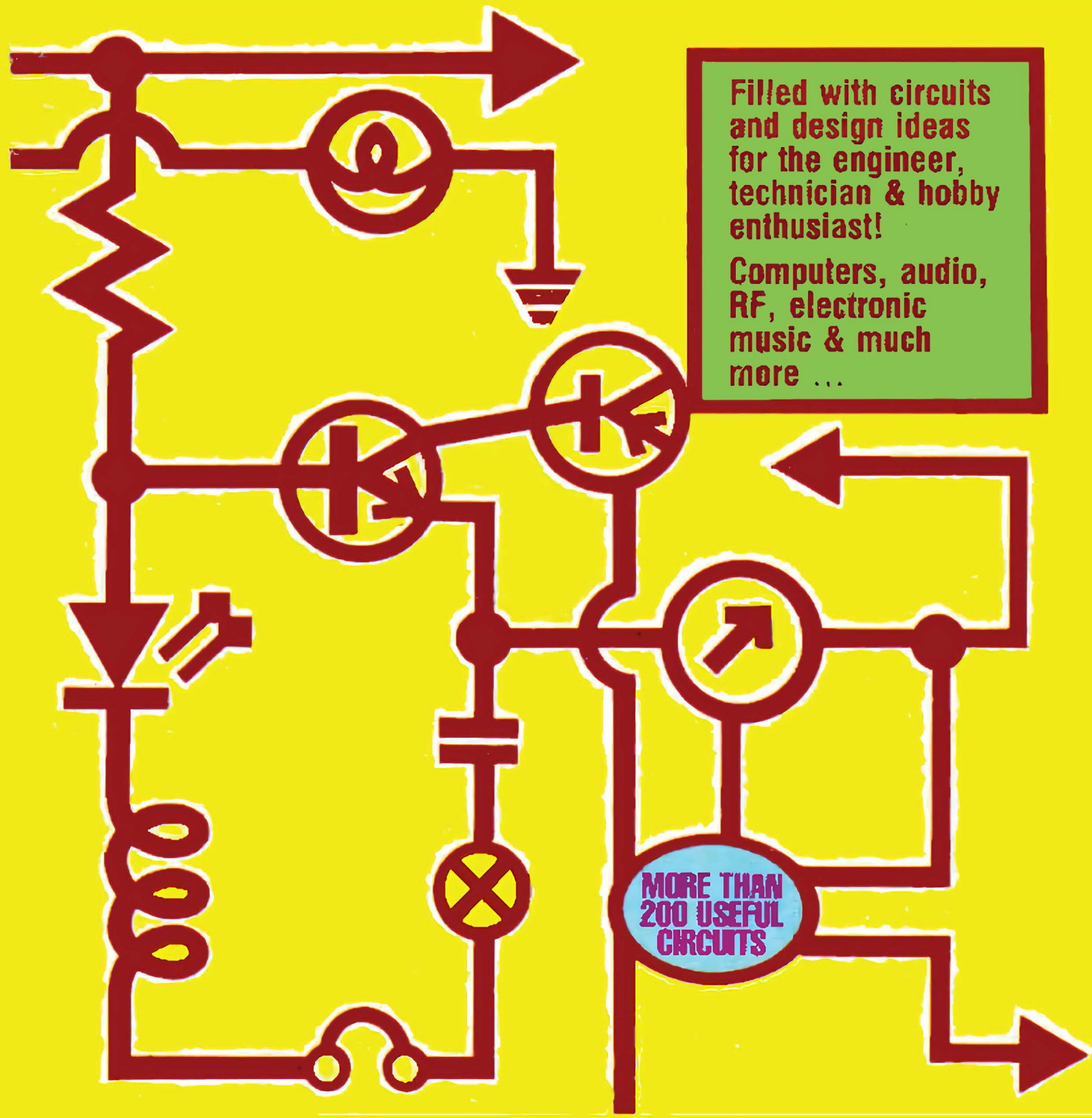
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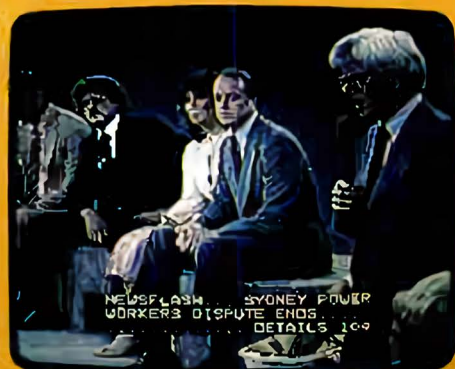
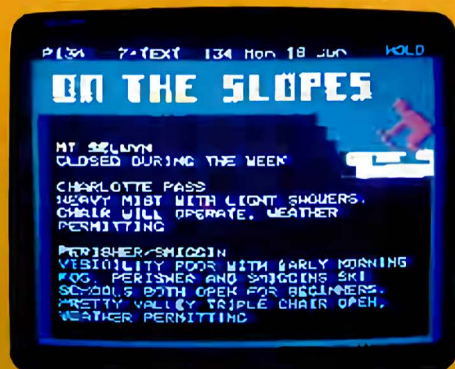
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Electronics Today's **Circuits**

COOKBOOK #5

Here it is at last! In response to lots of requests, we're happy to present another of our ever-popular collections of interesting and useful circuit and design ideas.

As with previous books in this series, it's basically in-
tended for anyone involved in designing electronic circuits
— not just for engineers and technicians, but for radio
amateurs, students and hobby enthusiasts as well. If
you're in any of these groups, we believe you'll find this
book of great interest and value.

To make the book of greater value when you're seeking
design inspiration, we've grouped the circuits according to
their area of function or application: RF, digital, audio,
automotive and so on. There are over 200 different circuit
ideas, grouped into 23 categories.

Many of the circuits in this book come from the very
popular 'Ideas for Experimenters' and 'Idea of the Month'
sections published each month in *Electronics Today* itself.
As a bonus, we've also added quite a few that haven't as
yet been in the magazine, due to lack of space.

Because many of the circuits have come from readers
or from the applications data of device manufacturers, we
haven't been able to test them all out in practice our-
selves. For this reason, although a lot of time and care
has been spent on preparing them for publication, we
can't guarantee them or answer any queries concerning
their detailed operation. So treat the book as a handy
source of ideas, not an infallible reference.

**NEW
RELEASE**

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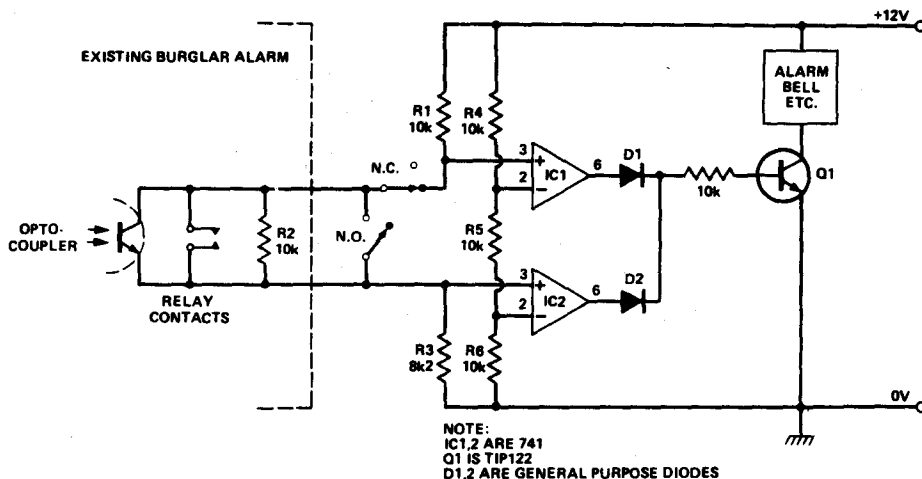
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Tamper-proof alarm

Recently I have started to install a burglar alarm in my home and, while planning the installation, I realised that I would require some form of tamper-proof or 'self-activating' bell. In other words, I required the bell to ring if the wires leading to it were cut or short-circuited. I consequently designed the following circuit.

The circuit is a window comparator and works as follows. R4, R5 and R6 are voltage dividers with one-third of the supply voltage across each. R3 is chosen so that $R1 \gg R3 \gg \frac{1}{2}R1$, noting that $R1 = R2$ (in practice, for R3 I used the next lowest standard value from R1, R2). Both non-inverting inputs of the comparators are thus kept lower than their respective inverting inputs.

If R2 is open-circuited, ie the leads to it are cut, the non-inverting input of IC1 is pulled high, thus taking the output high. If R2 is short-circuited the voltage across the non-inverting input of IC2 and ground is between one-half supply voltage and just over one-third of the supply



(depending on the value of R3), thus taking the output of IC2 high. The two outputs may now be ORed using any general purpose diodes and the output used to drive a suitable load, in my case a TIP122 Darlington transistor and a 1½ amp bell.

I would recommend other users to put a monostable between the diodes and the load as well as employing a battery back-up, although these were not necessary in my case. A five minute monostable

should be sufficient to keep the neighbours happy if the alarm is activated or tampered with. When installing this circuit, R2 should be situated inside the burglar alarm control unit across the existing relay contacts or an opto-coupler. When the alarm is activated, R2 is shorted. Tampering with the interconnecting cable can be detected and the bell enclosure may be protected with the appropriate normally-open or normally-closed microswitches.

Cheap high output alarm

Alec Phillips of Myrtleford Victoria has modified the circuit for the American siren from '555 timer applications' in ETI Circuit Techniques Vol 1. The sound is similar to the Victorian ambulance siren and the output is boosted by the addition of C2, C3, Q1, Q2, R1 and R2.

By driving one or two 8 ohm, 5 W horn speakers, the output at close range is quite deafening when using a 12 V supply.

Apart from the output, the only other changes to the original circuit are both timing sections of the 555's — this gives the required frequency and modulation for the particular type of sound required.

For a variety in sound modulation, R7 may be changed to 220 ohms, and R8 changed for a 100k tripmot with the wiper connected to pin 7 of IC2 as shown. This will change the sound to a rapid 'whip-whip' sound in one direction through to a 'wow-

wow' in the other direction. Modulation varies from about 6 or 7 Hz to about 1 Hz just short of the end of the wiper travel.

Note: If the alarm is to be used with two speakers and/or above 6 V, Q1 and Q2 must have moderate heatsinks. If two speakers are used at 9 to 16 volts it gives a better output with

470 µF capacitors for C2 and C3.

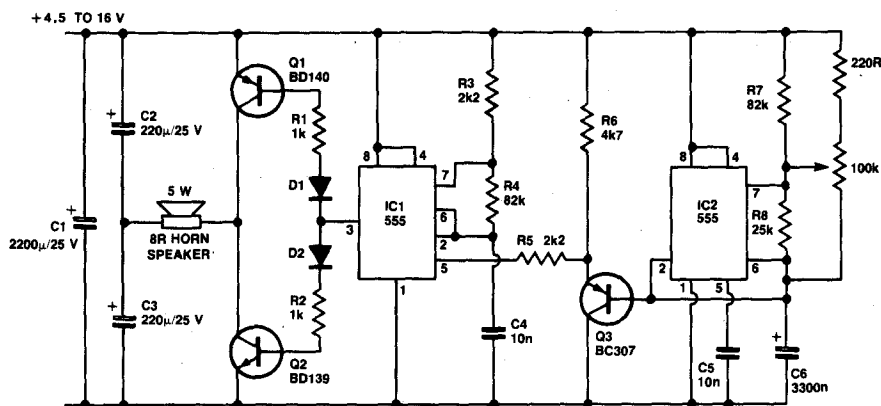
Below is a list of current consumption at different voltages using 220 µF for C2 and C3, and one 8 ohm speaker:

16 V, 420 mA; 12 V, 320 mA; 9 V, 250 mA; 6 V, 160 mA; 4.5 V, 100 mA.

Using two speakers, the cur-

rent increases to nearly twice the amount along with the sound output. As a further note, C1 is essential with any power source as it supplies power storage with the rapidly changing current drain.

Please consider other people when testing and using this alarm.



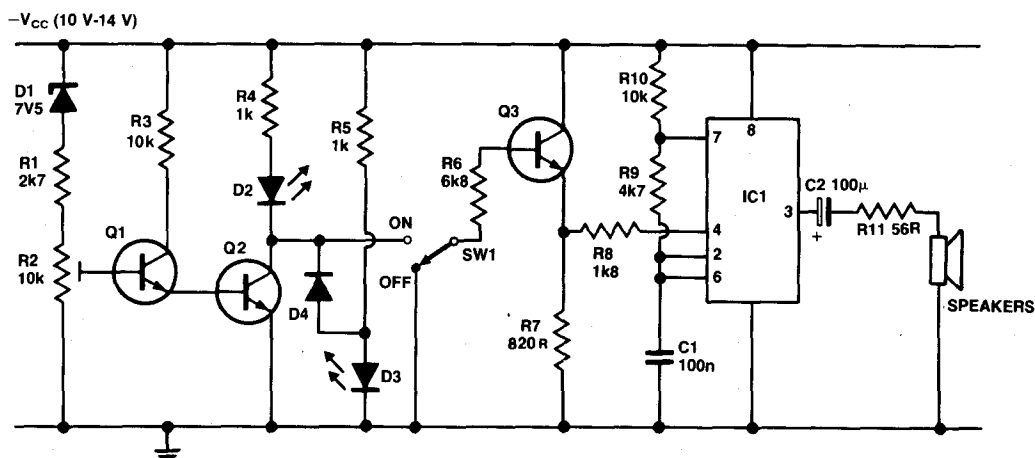
Low voltage alarm

A little ingenuity should find numerous applications for this circuit. It was designed by **R. Sinclair** of **Arnccliffe, NSW** who says that it provided reliable service in an amateur station.

This circuit was originally used in conjunction with an automatic mains/battery dc supply for transceiver operation. It detected the drop in dc voltage (mains supply normally 13.6 V, battery 12 V) to give visual and audio warnings of the voltage decrease.

It is suitable for any application requiring detection of a drop in normal dc supply voltage with the advantage of an audio warning. This would be particularly suitable in a vehicle where a visual indicator may be easily overlooked.

D1, R1 and R2 provide a stable voltage reference and the preset R2 is adjusted so that D2 lights under normal conditions.



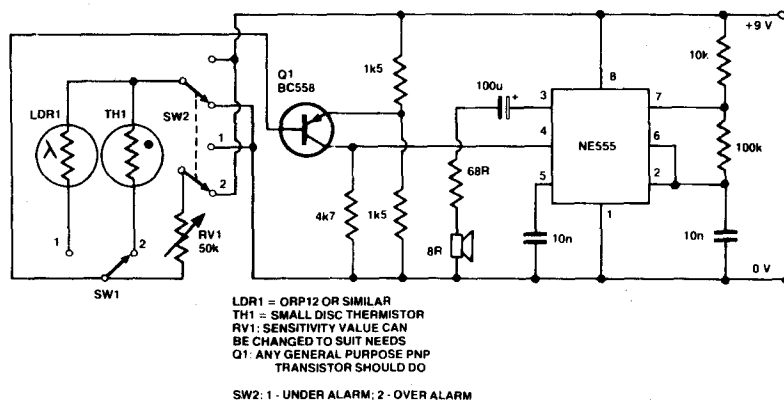
D4 is then forward biased, keeping D3 off.

When the input supply causes a voltage drop across Q2, D3 turns off and Q3 now turns on through SW1. The voltage on pin 4 (reset) of the 555 goes positive, enabling the 555 which is connected as an astable. The frequency is varied by R9.

To disable the audio alarm function, SW1 is operated cutting Q3 off, but D3 will still give visual indication.

D1.....	7V5 400 mW Zener
D2.....	green LED
D3.....	red LED
D4.....	1N914
Q1, 2, 3.....	BC108
IC1.....	555 timer
SW1.....	SPDT toggle

Versatile alarm



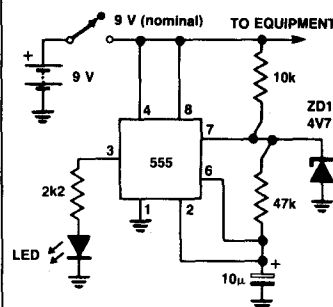
This versatile alarm circuit can be set to trip on light/dark/hot/cold, as an 'under' or 'over' alarm. **Justin Roff-Marsh of Oonoonba in Queensland** submitted the idea.

An LDR and a thermistor provide the appropriate sensing, selected by switch SW1. Switch SW2 sets the sensors to trip the relay as an 'under' or 'over' alarm. If SW2 is set to position 2, and SW1 to position 1, the alarm will trip when sufficient light falls on LDR1, reducing its resistance so that it provides bias to the base of Q1, via RV1 — the sensitivity control. With SW2 still on position 2 and SW1 on position 2, the thermistor is selected and the alarm

will be tripped when the thermistor reaches sufficient temperature to lower the resistance and provide enough bias to Q1 to turn it on. When SW2 is on position 1, bias is robbed from the base of Q1 when the light is above a preset level or the temperature is above a preset level, depending on which sensor is selected. When the light or temperature falls below the preset level — determined by RV1 — then Q1 turns on and the alarm sounds.

When Q1 turns on, it sets the 55, which commences to oscillate, its output driving the 8 ohm speaker, providing the alarm sound.

Low voltage alarm



J. Chubb of Kingsford NSW sent us his useful little circuit. It will light a LED when the supply voltage is above a certain level, and flash it when the batteries need replacing.

The values shown are for 9 V operation. Flashing starts at about 7V5 and the lamp won't light at all below 2 V.

The circuit consists of a 555 timer connected in the bistable mode and driving a LED. The trick is to connect a zener diode between pin 7 and ground. In normal operation pin 7 oscillates between one-third and two-thirds of the supply rail voltage V_{cc} . If $2/3 V_{cc}$ is greater than the zener voltage then the function of the 555 will be inhibited.

Thus to customise the circuit for your own requirements, decide on the minimum voltage that will operate the equipment correctly, and multiply by 2/3. This is the zener voltage. R may also need to be changed to suit the particular LED you use.

As originally constructed the indicator drew 7 mA at 9 V, falling to 5 mA at 7 V. If these values are likely to cause problems try the CMOS version of the 555, the 7555.

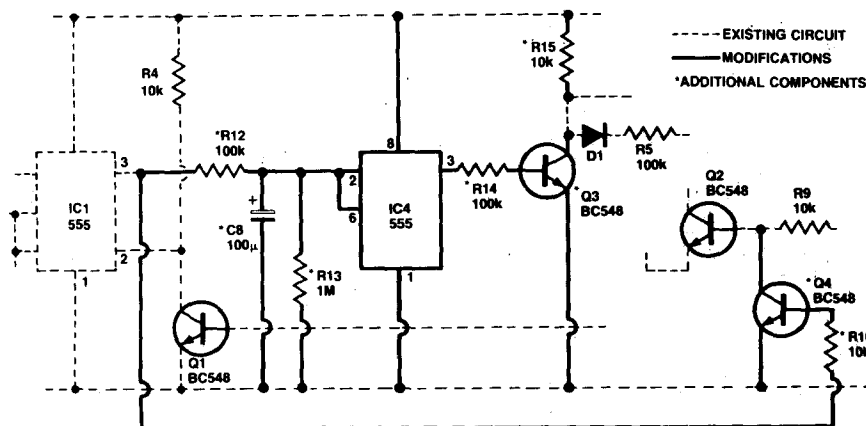
Car alarm modification

Anthony Park of **Middle Cove** has come up with a modification to the car alarm project, ETI-084. It provides an entry delay system, removing the need for an external switch and making the alarm easier to install, more convenient to operate and more difficult for thieves to disarm.

As the original alarm design allows for unlimited exit time, the modification required is simple yet more sophisticated than the usual entry/exit delay systems. And best of all, the extra parts should only cost about \$1.

When the alarm is triggered, pin 3 of IC1 goes low (about 0.6 V). This action initiates the entry delay provided by IC4, C8 and R13. C8, normally charged at 12 V, begins to discharge through R13 and after ten seconds or so the voltage at pins 2 and 6 of IC4 reaches 4 V.

This action sets pin 3 high.



thus turning on Q3 and allowing the relay to pulse via Q2 and also trigger off the 45 second reset delay as previously designed. After this delay time, pin 3 of IC2 goes high, switching on Q1 which resets IC1, followed by IC4 and IC2, completing the sequence.

The only change to circuit performance is that there is a delay time before the circuit is fully

reset due to the time required to charge C8. This should not pose any problems except when the alarm is initially turned on, taking about 17 seconds to charge C8 fully.

The purpose of Q4 is to disable Q2 so that the relay is not pulsed while C8 is charging, otherwise the horn would be beeping for 17 seconds when the alarm is first turned on.

This modification is very simple to install as only one track, from pin 3 of IC1, on the pc board has to be cut. All the other connections can be made directly by soldering wires on to the existing pc board. Veroboard can be used to house the extra components.

The alarm should have a ten second delay before the horn or siren begins to sound.

Modification of the ETI-300 car alarm

Noel Nelson of Christchurch New Zealand wrote that he found the ETI-330 excellent except for one flaw.

If an inside switch was used to turn the unit on and off one could get in the car, shut the door and not trigger the alarm because the inside light would be extinguished and C1 would no longer be charging.

So I added a courtesy light extender (Figure 1) which holds the light on for about three seconds after the door is shut. This simply wires straight across the door switch and can easily be concealed in the roof lining above the courtesy light. Q1 doesn't dissipate much heat as it is only on for three or four seconds. (This circuit is not an original.)

The exit delay then needed to be extended; this was simply done with a 555 timer and a PNP transistor. See Figure 2. This also means that you don't have to make such a hurried exit when you're carrying armfuls of shopping.

I also wanted to fit switches under the bonnet and in the petrol cap but didn't want any

delay in the tripping of the alarm (so the battery lead couldn't be cut). The modification shown in Figure 3 requires 12 V, from anywhere in the car, to be switched to a common 'instant trip' wire.

The exit delay and instant trip circuits were easily placed on the same size pc board beside Q3 and IC3 respectively.

After having a set of driving lights stolen, I designed Figure 4 for protecting their replacements. The circuit uses the earth path through the lights to hold the non-inverting input of a 741 low. When either the earth path or the 12 V line to the lamp is cut, the 741 changes output state (to 12 V) and is used to trigger the instant trip facility.

The 741 and associated circuitry have no effect on the lights or the alarm sensitivity.

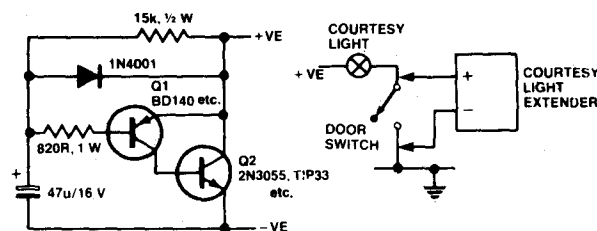


Figure 1. Courtesy light extender.

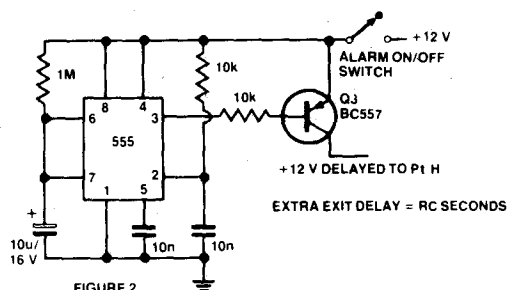


Figure 2. Alarm exit delay.

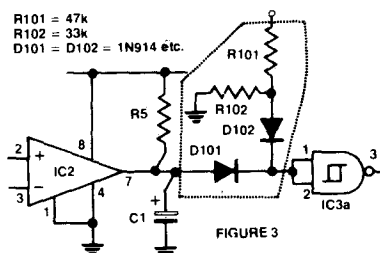


Figure 3. Instant trip modification.

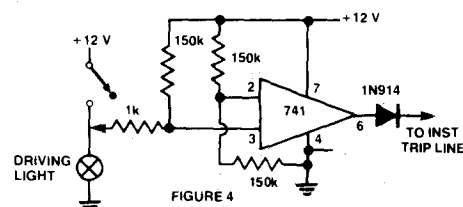
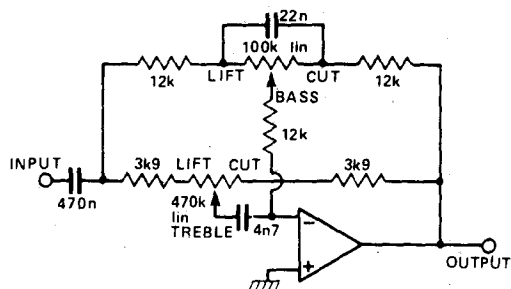


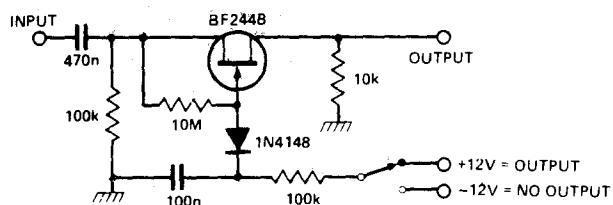
Figure 4. Driving light protector. Two are needed for two lights if double pole relay contacts are used.

Bass and treble tone control

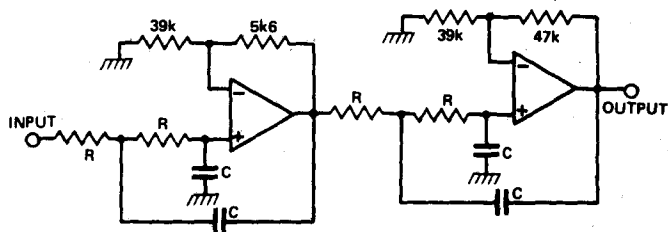


The op-amp can be any type suitable for audio work, e.g. TL071, NE5534N, etc.

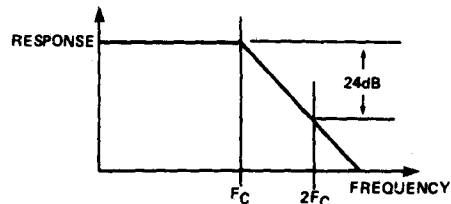
FET audio switching



Scratch filter



4th ORDER LOW PASS

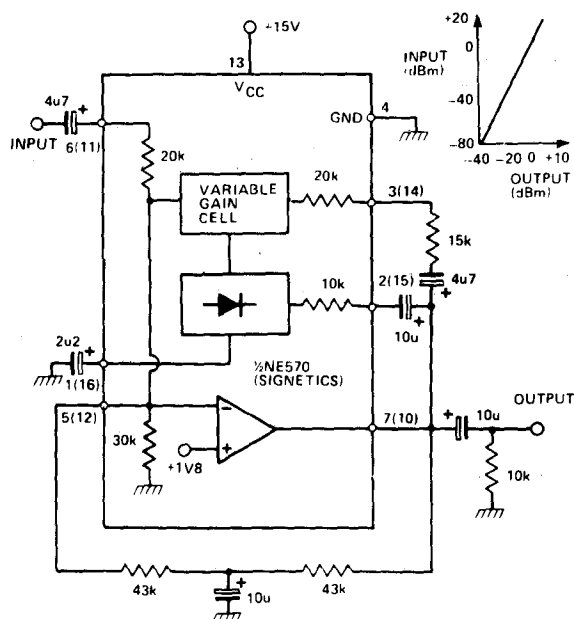


Input must have a DC path to ground
Roll-off slope = 24 dB/octave
Overall voltage gain = x 2.6 (8.3 dB)
Op-amps are 741's or RC4558

F_c	C	R
10 kHz	1n5	10k
7.5 kHz	1n5	14k
5 kHz	1n5	20k

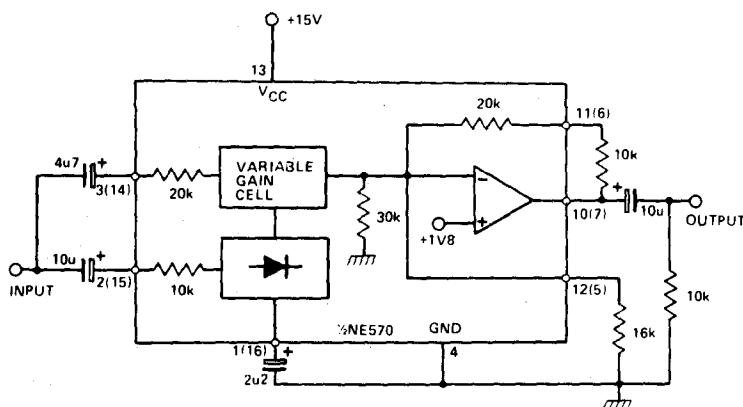
(5% tolerance)

Two-to-one compressor

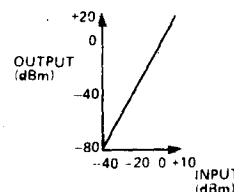


The pin numbers in brackets refer to the second circuit in the IC. Circuit can be used as a preconditioner in a noise reduction system.

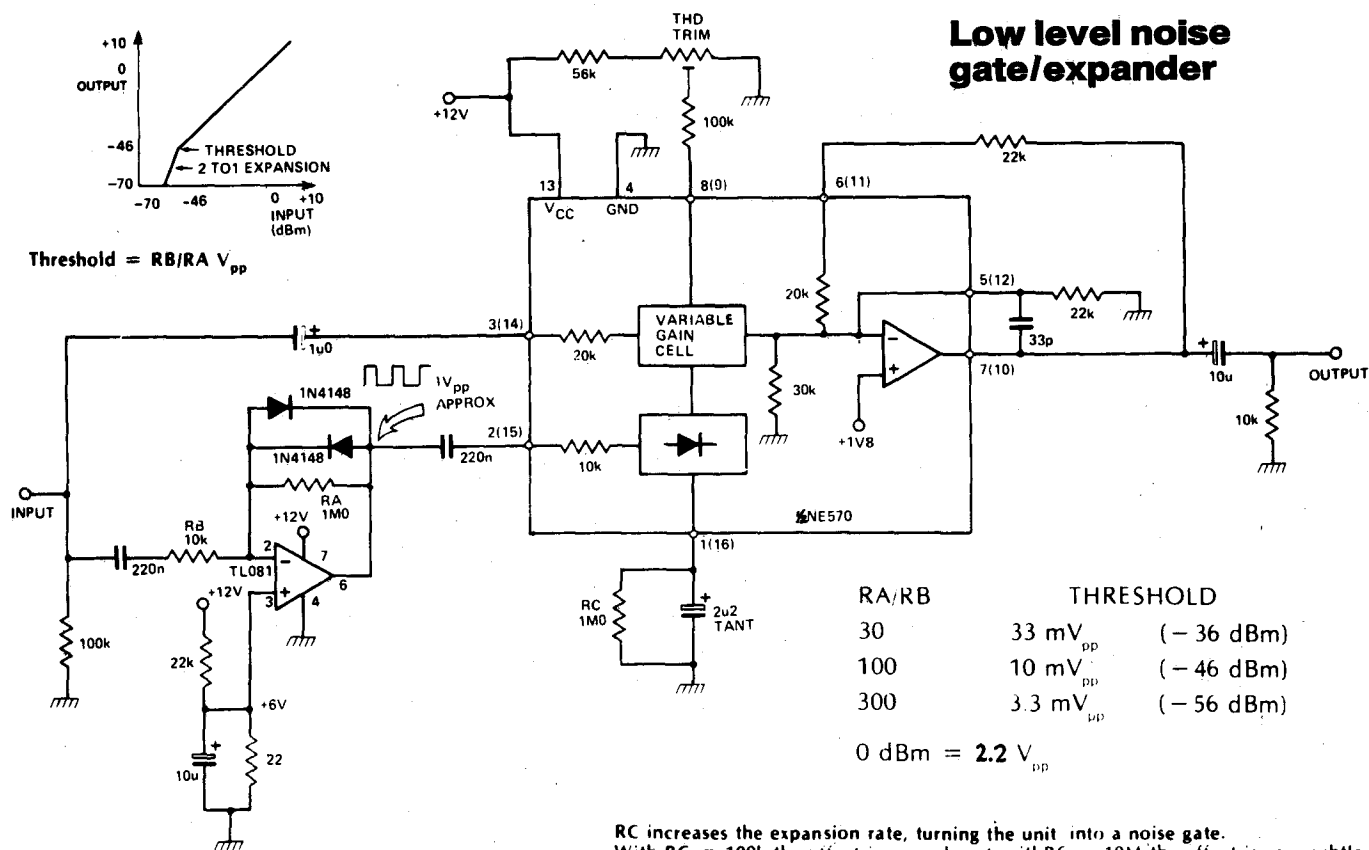
Two-to-one expander



Circuit can be used to expand previously compressed signals, and hence to effect an overall noise reduction

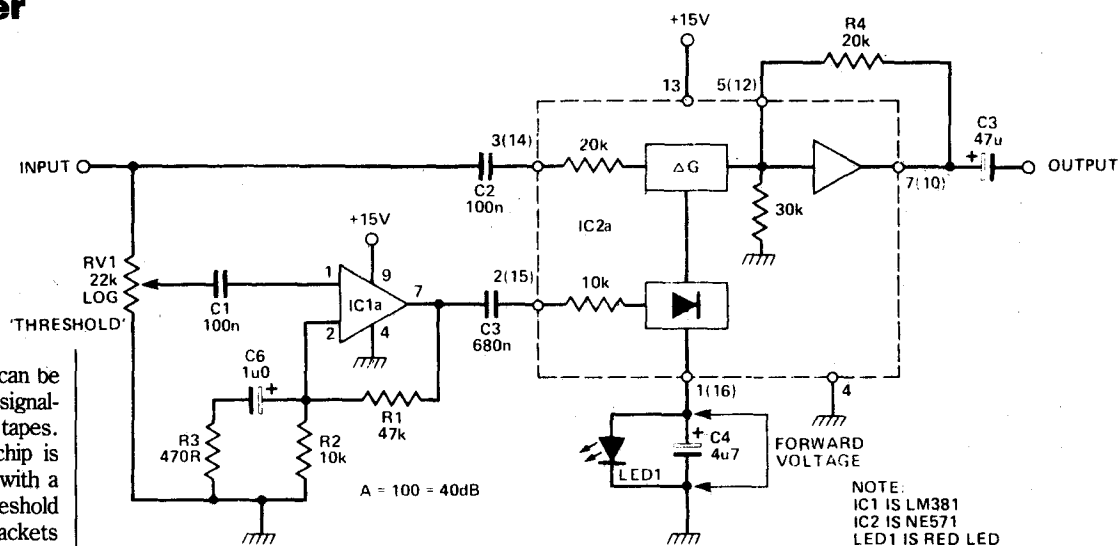


Low level noise gate/expander



RC increases the expansion rate, turning the unit into a noise gate. With RC = 100k the effect is very abrupt; with RC = 10M the effect is very subtle.

Audio expander

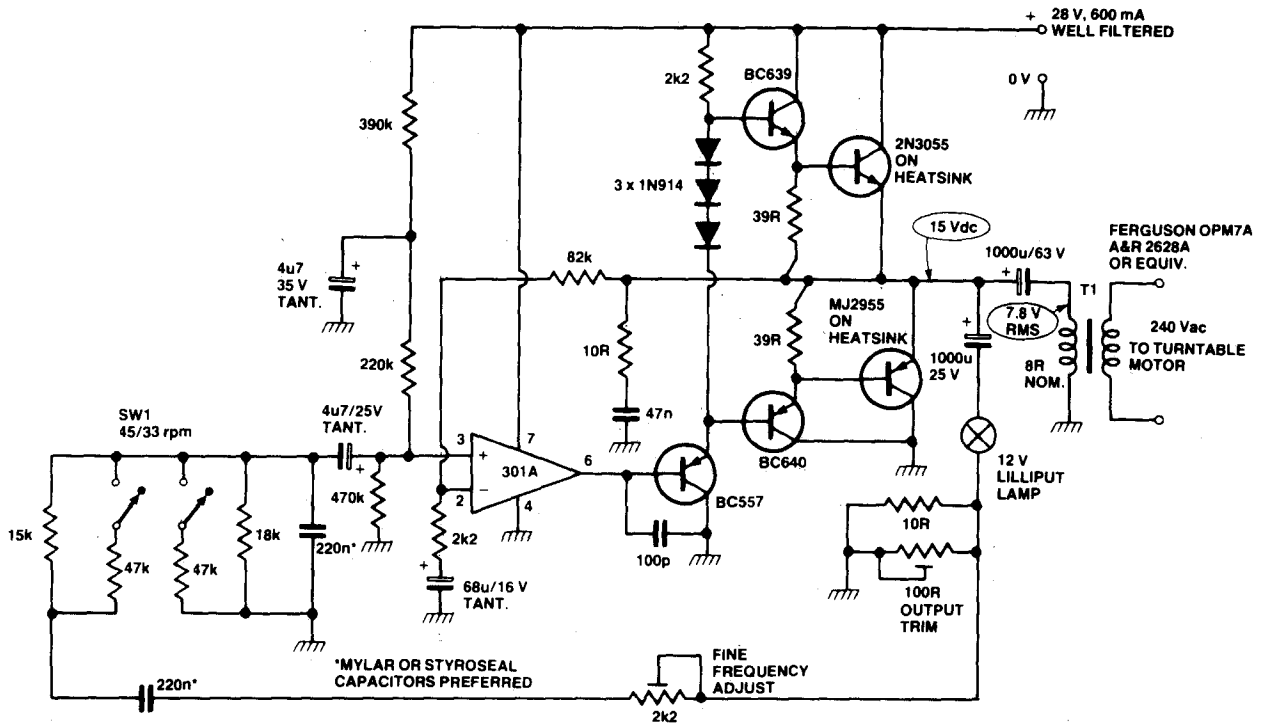


This simple expander gate can be used to provide improved signal-noise-ratio on records and tapes. The NE 571 compander chip is used here as an expander with a red LED used to set the threshold on pin 1. Pin numbers in brackets are for the other 'half' (the NE571 is a dual compander). For stereo operation, the two threshold LEDs should be matched for forward voltage.

The 381 amplifies the input signal by 40 dB. This is rectified by the internal current mirror of the

NE571 and smoothed by C4. When the voltage reaches the forward voltage of the LED, it draws current and limits the current to the gain cell. This then provides linear operation above the threshold.

FOR STEREO USE, THE FORWARD VOLTAGE OF THE RED LEDs SHOULD BE MATCHED (ABOUT 1V5) (INJECT SIGNAL TO L+R UNTIL BOTH LEDs ARE LIT)



Turntable speed controller

This device varies the supply frequency to the motor of a synchronous turntable. In addition, provision is made for 45 rpm drive without the tedium of belt changing — a useful feature for owners of expensive single-speed turntables such as the Linn Sondek.

Other advantages include steady voltage output and low distortion compared with the mains. The unit may also be used to slow down those pop recordings that seem to

be recorded at slightly high speed.

The circuit is based around the ETI 452 Guitar Practice Amp (January 1980, the ETI 453 General Purpose Amp Module of April 1980 uses the same circuit). There are some modifications, shown in the circuit shown here, converting the original to a power Wien Bridge oscillator using a 12 volt bezel lamp as a stabiliser. The output transformer is from an old valve hi-fi amp. Others with 30:1

ratio and 12 watt (min) rating will be fine. A power transformer is not satisfactory.

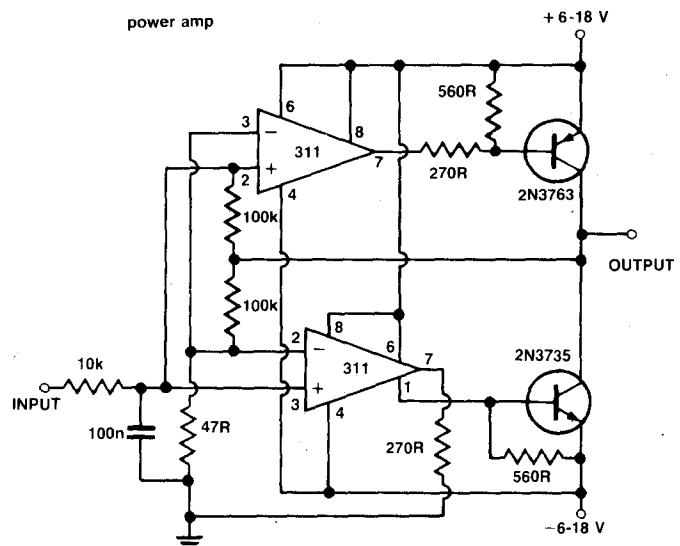
Set the 100 ohm trimpot to give 240 Vac with the turntable connected. Adjust the 2 k trimpot for correct speed (using a strobe disc). Small adjustments may need to be made to the Wien Bridge components. Add (switched) resistors for 45 rpm.

Switching power amplifier

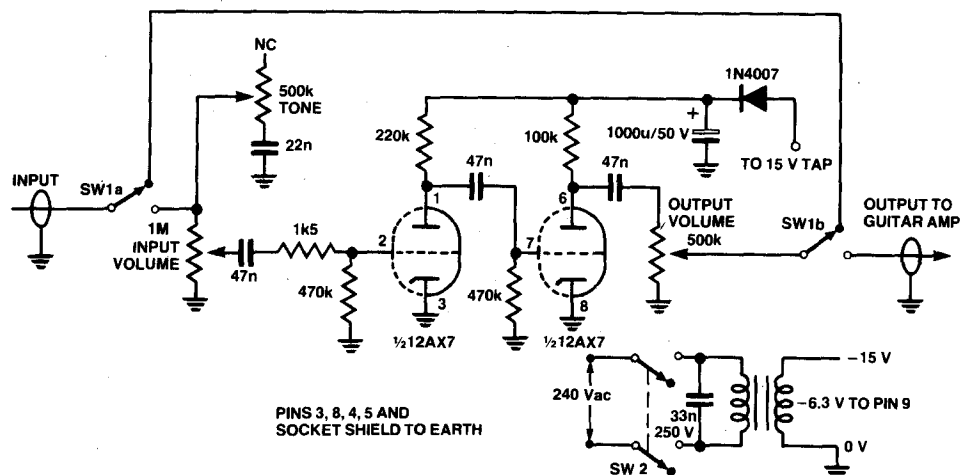
A pair of 311 comparator integrated circuits are used as a driver stage for this class B power amplifier.

The devices are configured such that the output transistors (type 2N3763) conduct only when alternate input cycles exceed a small preset threshold voltage.

Negative feedback substantially reduces the cross-over distortion otherwise characteristic of this type of amplifier.



Valve distortion unit



If you really want a valve distortion unit, **Jeff Parkes** of **Collingwood Victoria** has designed one.

I built this effect pedal in an aluminium box with dimensions of 130 mm x 75 mm x 55 mm. It is almost hum and noise free and

sounds great with a gutsy guitar such as the 'Les Paul' type.

I have left it running for several days and the performance has remained constant. The transformer is a 2155 and SW1 is an audio quality DPDT foot-switch.

Crossover performance improved (Zobel network)

When designing crossover networks, problems are encountered due to the reactive nature of the speakers. This problem can cause ringing, and more importantly the roll-offs will not occur at the frequency that the normal design calculations would indicate. It is pointless to design a crossover on the assumption that the impedance remains at a constant value throughout the operating range.

In fact a moving coil speaker looks like an inductance and a resistance in series. Because of the inductance the impedance of the speaker increases with frequency. It is not unusual to find that the impedance presented by a nominally 8 ohm speaker is nearer 15 ohms at 3 kHz.

This problem can be overcome by shunting the speakers in the proposed system with a series resistor-capacitor combination. If the values of these components are correctly chosen, the speaker will look like a nearly pure resistive load to the crossover. Obviously this ensures that the latter rolls the response of the

speakers on and off at the calculated frequencies without problems.

The circuit is shown in Fig. 1, and the component values are determined as follows. Feed the speakers with a sine wave at the desired crossover frequency via a 100R resistor (see Fig. 2). Measure the output voltage at the output of the generator (V_1) and the voltage across the speaker terminals (V_2). The impedance of the speaker Z can now be determined by the equation: $Z = \frac{100 \times V_2}{V_1 - V_2}$

The DC resistance is now measured across the speaker terminals and R is made equal to this. C can now be determined from the equation: $C = \frac{Z - R}{2\pi f R^2}$

where f is the crossover frequency in Hertz and C is given in Farads. The speaker and network now present a resistive load equal to R and the crossover can safely be calculated on this assumption.

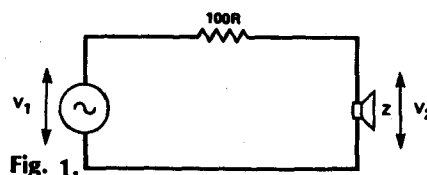


Fig. 1.

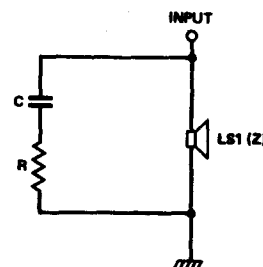


Fig. 2.

Battery voltage Indicator

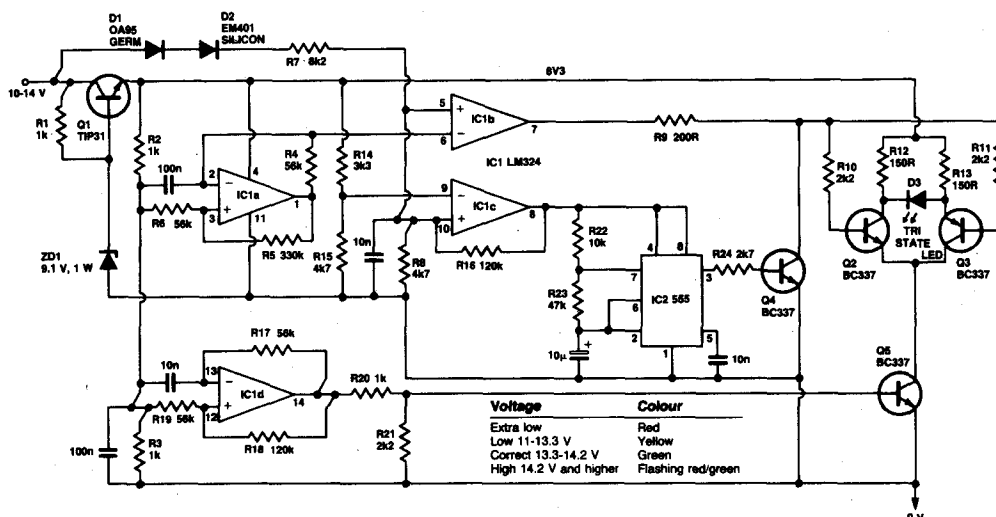
D. Baillie, Moe Vic.

This circuit uses a single tri-state LED to indicate the voltage of the car battery. The different colours of the LED make it possible to indicate four levels of voltage: red is less than or equal to 11 V, Yellow is 11-13.3 V, green is 13.3-14.2 V, flashing red and green is 14.2 V and higher.

The voltage regulator, R1, Q1 and ZD1, provides a constant voltage for the circuit while the supply voltage varies with the normal operation of the car. IC1a is an oscillator which produces a sawtooth waveform with a voltage of 3.55-4.74 V at a frequency of approximately 200 Hz. This is output at pin 2 and is connected to pin 6 of IC1b.

When the voltage of the car's battery rises, say from 8 V, the voltage applied to IC1 pin 5 via D1, D2, R7 and R8 is much lower than that of pin 6, so the output at IC1b remains low. Therefore Q3 is biased on via R9 and R11, and Q2 is biased off via R9 and R10. The tri-state LED (a Radioshack device) should be inserted so that it glows red in this mode.

For the moment consider that



Q5 is biased on, but it will be discussed in detail later.

As the voltage rises on IC1 pin 5 it starts to intersect the waveform, switching the tri-state LED on and off from red to green at approximately 200 Hz.

The mark/space ratio of the square wave output at IC1b varies as the battery voltage rises. At about 12 V, when the mark/space ratio is equal, the LED appears to be yellow. As the voltage continues to increase the green becomes more dominant until it is bright green at

about 14 V.

When the voltage rises above 14.2 V IC1c triggers and its output goes high, enabling the timer IC, which has an output of 1 Hz. R16 provides a small amount of positive feedback to enable a clean switching operation without creating too much hysteresis on the switching voltages.

Q4 is then turned on and off at 1 Hz, in turn biasing Q2 off and Q3 on at the same frequency, making the LED flash red and green.

Q5 is driven on and off at

about 2 kHz by the oscillator IC1d, enabling a much higher current to pass through the tri-state LED making it much brighter.

Final trimming of the triggering voltages and the colour change voltages can be varied by replacing D1 and D2 with various germanium and silicon diode combinations, making use of their different Vd characteristics.

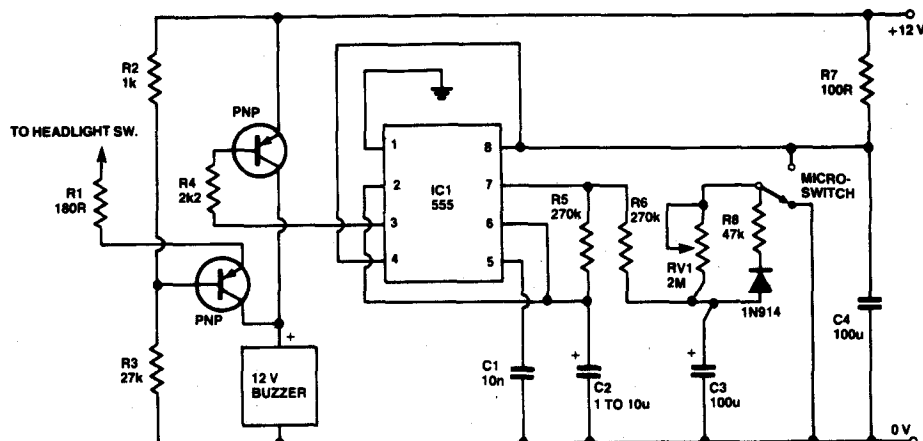
2 x silicon = 1.4 V
2 x germanium = 0.4 V
1 silicon + 1 germanium = 0.9 V

Choke and headlight warning

D.K. Modra of Elizabeth South SA kept forgetting to push in the choke and/or switch off the headlights of his car. So he designed this circuit to sound a buzzer intermittently, after a preset period, when the choke button had been pulled out.

The microswitch is mounted on the carburettor so that C3 slowly charges up via RV1. When the voltage on C3 reaches two thirds of Vcc IC 555 operates in an astable mode as long as the choke control is 'out'. Oscillation ceases when the choke button is pushed in, discharging C3 via R8 and the diode.

The buzzer sounds continuously if the lights are left on after the ignition is switched off.

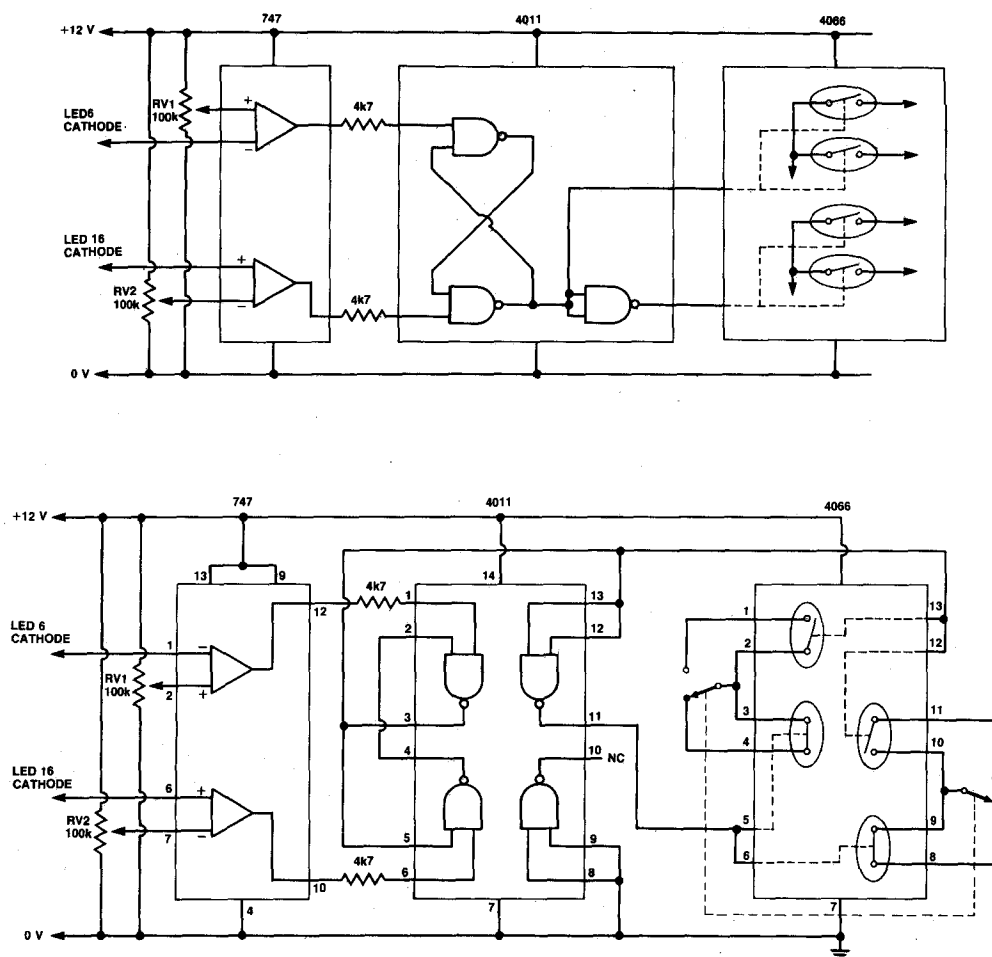


LED tacho autoranger

A modification which automatically ranges the LED tacho project, ETI-324, August 1980, has been designed by **Bill Keenan** of **West Heidelberg Victoria**.

The flying leads to the cathodes of LEDs 6 and 16 sense the drop in voltage as the LEDs turn on. This is compared to the preset voltages produced by RV1 and RV2, by the comparators of the 747. The highs and lows are fed into the 4011, which is wired as a flip flop. The 4066 and one gate of the 4011 are wired as a DPDT switch, which eliminates the switch in the tacho circuit. One gate of the 4011 is not used, so its inputs are earthed. Pins 4 and 8 of the 4066 go to low range calibration, and pins 1 and 11 go to high range calibration.

RV1 adjusts the revs at which the tacho swaps to low range and RV2 adjusts the revs at which it swaps to high range. The tacho must be re-calibrated after this modification, due to the 90 ohm resistance across the switches in the 4066.



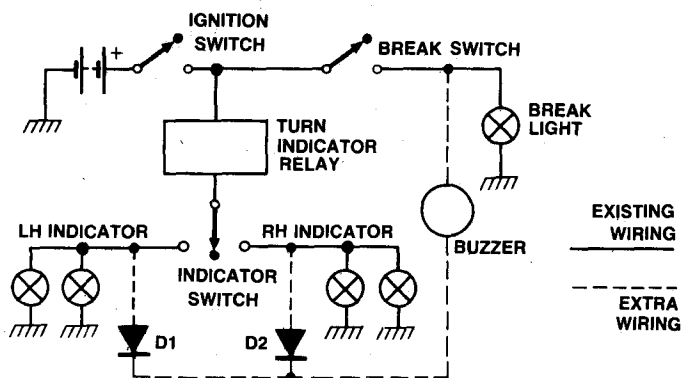
Buzzer inhibitor

Kevin Lowton of **Seven Hills NSW** fitted this circuit to his motorbike where it performed faultlessly for twelve months.

Some motorcycles have a buzzer that sounds in conjunction with the turning indicators to remind the rider to cancel them. This system works well, but it suffers from the problem of irritating both the rider and surrounding motorists when the rider is caught in traffic. What is needed is a foolproof way of inhibiting the buzzer while the bike is stationary. This simple circuit contains only three components yet it not only inhibits the buzzer but acts as a brake light fail indicator as well.

When either blinker is selected, current is fed through the buzzer via D1 or D2 and flows to earth via the brake light. When the brakes are applied the buzzer is shorted out. If the brake light goes open circuit or if the brake light switch needs adjustment then the buzzer will not work.

The whole circuit is small enough to fit inside the headlight assembly of most bikes, with the added advantage that all the wiring is usually accessible there.



Car fuel gauge

I had the need for an accurate fuel gauge so I set about designing a digital model. The maximum readout of this unit is either 99.9 gallons or 99.9 litres. This could easily be expanded but I doubt the need would arise in most family cars or recreation vehicles.

As most fuel gauge 'senders' put out about 5 V when the tank is empty, 0 V when full, I decided to use a load-preset/countdown method.

Looking at the circuit, the output from the sender is fed via D1 to IC1's non-inverting input. D1, R7 and C1 reduce input fluctuations caused by petrol slosh. R1 and RV1 set the voltage gain of IC1, the output of which is fed to the input of IC2, configured as a voltage-controlled oscillator. RV2 and C2 set IC2's nominal output frequency. The output from IC2 is gated through a NAND gate, inverted and fed into the CLK input of the presettable up/down counter comprised of ICs 9, 10 and 11. These are all 74LS192s with the carry output of the first fed to the clock input of the following stage, etc. Note that the output of IC2 is clipped by the action of ZD1 to 5 V to suit the input of IC4.

A 555, IC3, and associated components sets the counter update period. IC5 is a dual monostable multivibrator. IC3 begins with its output being low, which allows the CLK pulses to be fed to the counters. IC3 times out and pin 3 goes high, stopping the CLK pulses and triggering the first

one-shot, IC5a. This latches the 9368s. When latching has finished, the second one-shot is triggered (IC5b), which loads the preset values present on P0 to P3 of each of the '192 counters. These preset inputs are wired to the binary value of the car's fuel tank capacity. Note that the LED displays do not require resistors. Only the

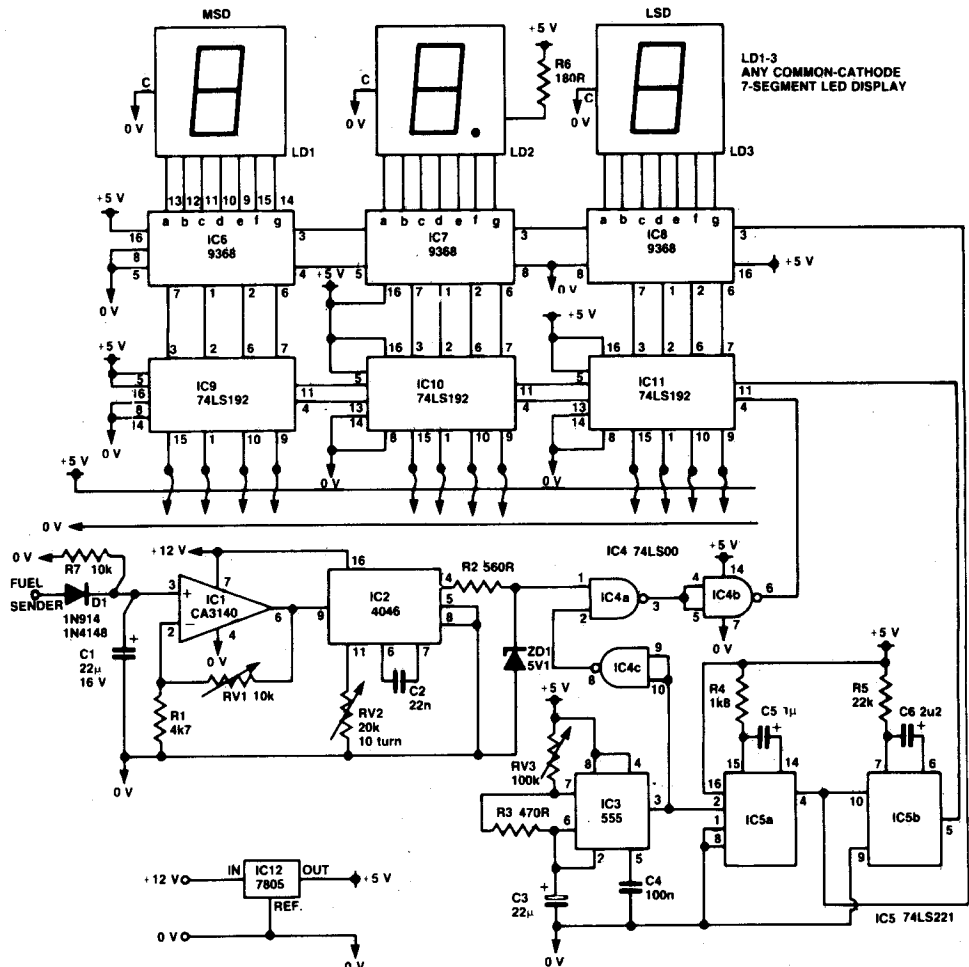
decimal point on LD2 requires a current limiting resistor.

To calibrate it, RV3 is set to the desired update period; RV1 is set so that when the tank is empty, the voltage on pin 6 of IC1 is 12 volts; finally, once these calibrations have been done, RV2 is adjusted so that the displays read a known value of fuel in the tank —

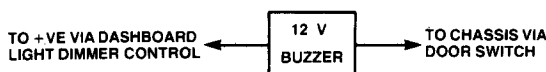
preferably fairly low (1 or 2 gals, 4-5 ltrs).

In this circuit, the reading is in gallons, determined by the VCO frequency. Reduce the value of C2 to read in litres — some experimentation may be necessary.

A suitable small heatsink should be bolted to the tab of the 7805 (IC12).



Parking light reminder



There are many different circuits for devices to remind you to switch off your parking lights. This must surely be the cheapest and simplest.

The buzzer requires only two connections to the vehicle: one to a door courtesy light switch, the other to the positive battery terminal via the dashboard light

dimmer control.

It's very simple to operate. The buzzer will sound when the parking lights are on and you open the car door. This warns you to turn the lights off.

If you need to have the parking lights on and the door open, you can silence the buzzer by operating the dashboard dimmer control.

Monster flasher

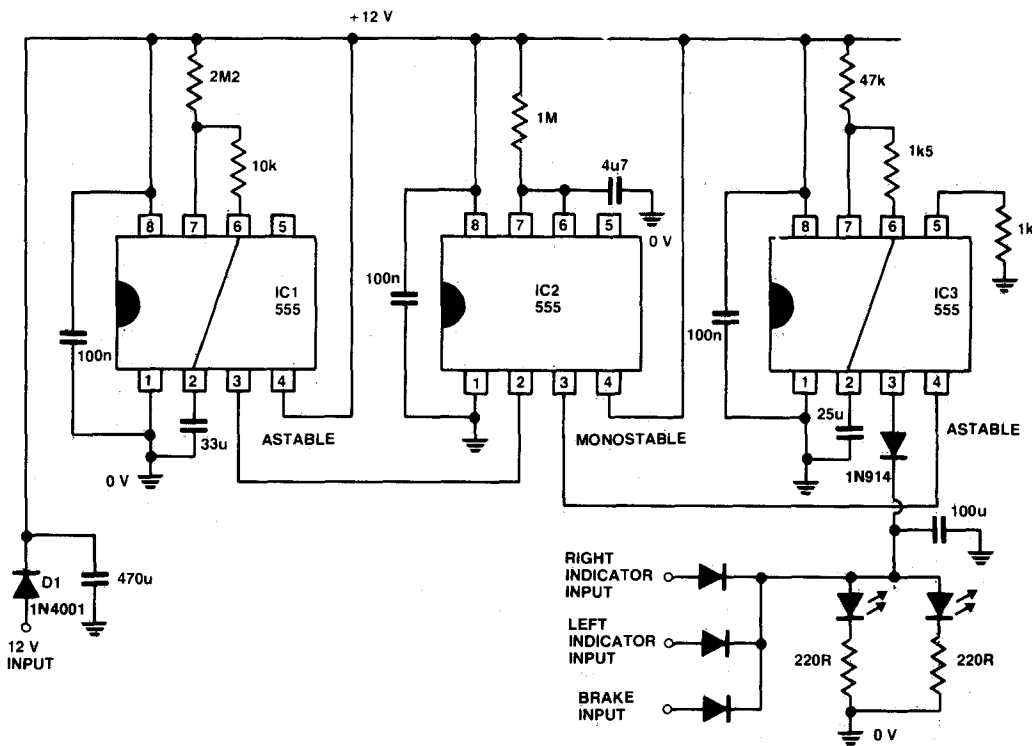
Andrew Stewart of Gumdale Queensland has a little monster which sits on the dashboard of his car and flashes its eyes (LEDs) with the indicator and brake lights. Now many of his friends want a 'flashing eyed' monster. He sent us a copy of his most advanced unit.

As the ignition system in a car is often noisy D1 is needed to isolate the 470uF capacitor from the 12 V supply.

IC1 555 gives a time delay of over a minute and when it finishes counting it sends a pulse to IC2 555. The output of IC2 then goes high for approximately 4-5 seconds. This, in turn, causes IC3 to oscillate and the monster's eyes blink.

The 1k resistor brings the duty cycle close to 50%. The 100 uF capacitor on the output of IC3 makes the eyes look as if they are fading in and out.

The monster I used for mounting the LEDs in was a cheap plastic lizard. The ICs can be mounted on Vero board and placed inside a matchbox up under the dashboard.



Avoid flat batteries

B.P. of Putney NSW has obviously forgotten to switch his car lights off on a dark winter's morning and come back, after a day's work, to find that the battery is flat.

This device has been on my car for several years now and I've found that it is extremely useful. Despite the many complicated circuits published, all that is needed is a solid state buzzer, a resistor and a couple of diodes.

There are two possibilities to overcome this problem.

1. Insert a switch between the resistor and earth, but don't forget to turn it back on later.
2. Add a relay and a push button switch (on the dash board), as in Figure 2, and you can override the system. After you have switched off the lights the relay will drop out, leaving the device reset for further protection.

When the ignition is switched on both sides of the buzzer are held at a nominal 12 V, so there is no sound. The moment the car is stopped and the ignition switched off, current can flow from the lighting circuits through the buzzer and the resistor to earth. It is a very penetrating sound, so there is no way you will leave the lights on!

The connections are made to the passive side of each switch. For a positive earth system, just reverse all the diodes and the buzzer. Make this up on a small strip of bakelite or insulating material and attach it to the glove box under the dash. It will outlast the car.

The only problem is that if you really want to park the car and leave the lights on for a short time, you have to put up with the buzzer.

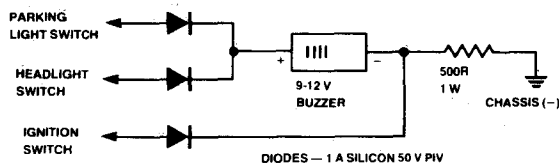


Figure 1. A buzzer warns you that you have left the lights on.

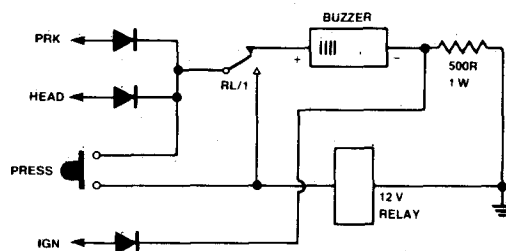
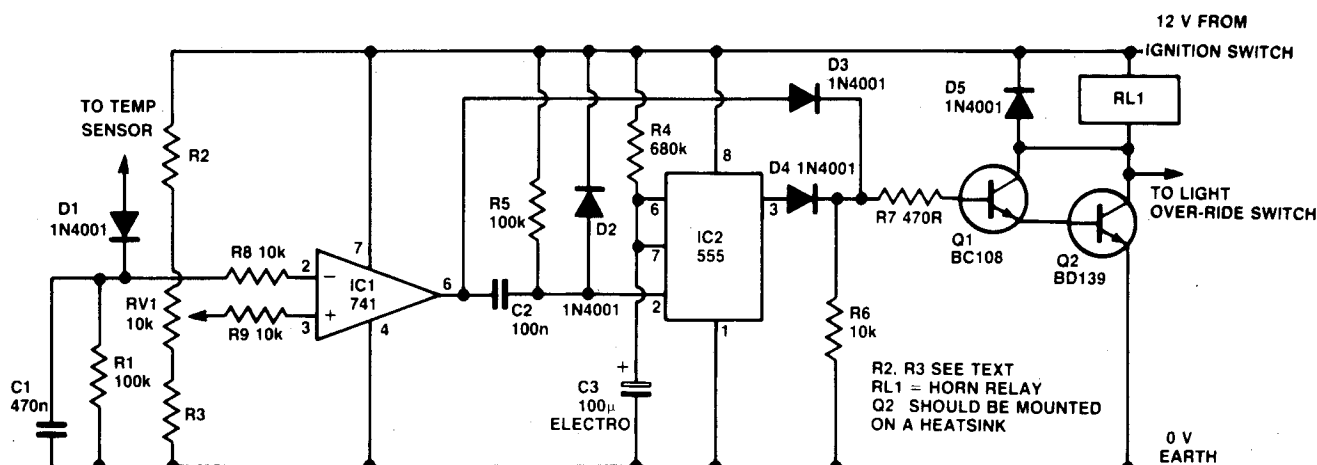


Figure 2. Over-riding the system.



Thermatic fan control

L. Lawrence of Sanderson NT has designed a thermatic fan control which is relatively universal for any vehicle.

The circuit was designed because the original sensor supplied with the fan failed. The only requirement of the vehicle is that it must have electronic temperature sensing, and not 'go — no go' sensing.

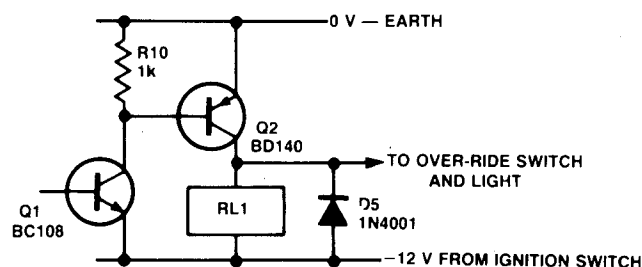
D1, C1 and R1 form a sample and hold circuit for vehicles with pulsing voltage stabilisers for the instruments e.g. some Ford models. IC1 is in a voltage comparator configuration with RV1 setting the switching voltage.

R2 and R3 are chosen to give

a suitable range for RV1 to operate in particular vehicles. In the prototype R2 and R3 were not used, which meant that small movements of RV1 gave large temperature variations.

C2 and R5 ensure a short trigger pulse to the 555 timer when pin 6 of IC1 goes low, while D2 prevents damage to IC2 when IC1 goes high. IC2 is connected in the monostable configuration and C2 and R4 set the delay to about one minute.

D3, D4 and R6 form an OR gate to drive the Darlington coupled Q1 and Q2 relay driver pair. D5 is to prevent damage to the relay driver Q2.



No power supply decoupling was used in the original prototype because the 741 is working in the comparator configuration. R8 and R9 were used as links to connect the 741 inputs so that the comparator switched in the correct direction.

With RV1 connected to pin 3 of IC1, the temperature sensor must go negative for correct

operation of the circuit. For sensors that go positive for higher temperatures, connect the circuit the other way around.

The circuit was designed for negatively earthed vehicles but can be adapted for positive earth vehicles by modifying the circuit as shown. The fan will run for about one minute after the engine is started.

Tacho modification

Here's a particularly interesting application of the ETI-324 LED tacho project we published in October 1980. It was sent to us by Clyden Anderson of Woolloongabba Qld, who had a requirement for a fuel flow meter.

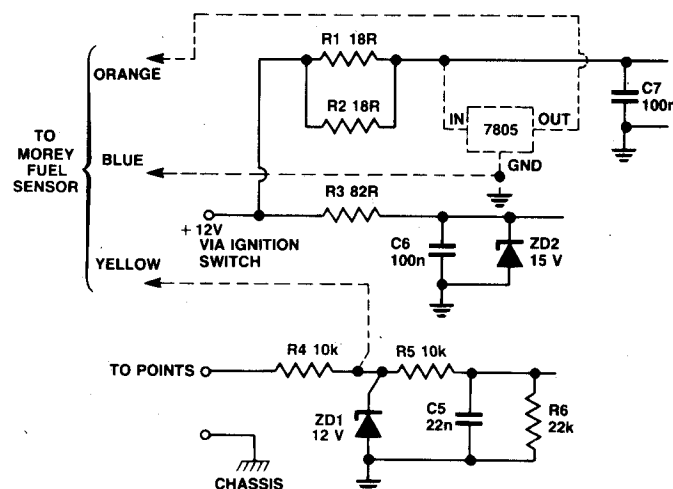
Present designs of digital fuel flow meters require some time to read, especially if the level is fluctuating. What he wanted was a 'relative' display for monitoring fuel consumption. This was

easily done with a simple modification to the ETI-324, and a Moray fuel flow sensor.

A 7805 regulator supplies five volts to the Moray sensor. Suitable values for the driving range of the tacho are C1, 100µ and C3, 3µ3. For the tuning range leave C2 at 220µ and C4 at 4µ7.

Calibration is simple, knowing the fuel sensor calibration and having a square wave generator to adjust RV1 and RV2 for full scale deflection.

----- ADDITIONS
 ——— ORIGINAL CIRCUIT



Pushbutton wiper delay

This circuit is designed to pulse a relay to initiate the wipe sequence.

IC3 is connected as an astable to advance the Johnson counter IC1 and the decade counter IC4.

IC4 is used to address the multiplexer IC2. IC5 is connected as a monostable to give a short pulse when triggered.

When the 'start' button is pressed the flip-flop will reset, enabling IC1 and disabling IC2. This will also trigger IC5 and pulse the relay, initiating a wipe. A momentary reset will also be applied to IC1.

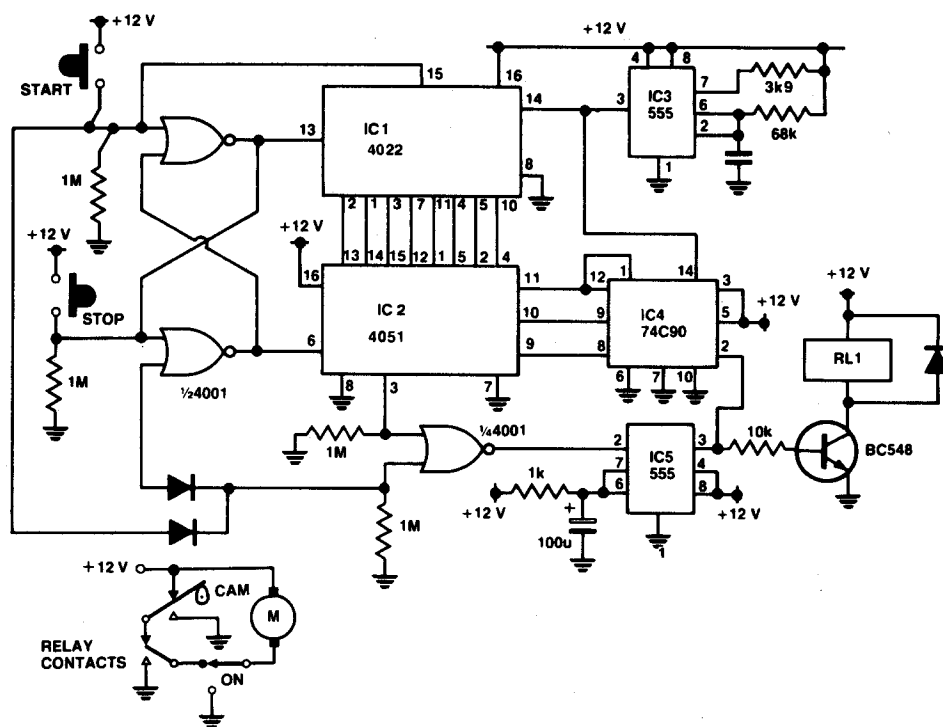
The outputs of IC1 will begin to go high in turn (every two to three seconds) from one to eight until the 'stop' button is pressed. This will set the flip-flop, disabling IC1 and enabling IC2. IC5 will be triggered and another wipe will be initiated.

The pulse will also reset IC4. IC4 will continue to count up from zero until the output of IC2 reaches the high output on IC1.

IC5 will then trigger again, in-

itiating a wipe and resetting IC4.

This programmed time interval will continue until the 'start' button is pressed again to either increase or decrease time between wipes.



Audio turn signal indicator

Todd Gorman of Swan View WA found the flasher unit of his car to be barely audible, especially when the radio was on, so he designed this circuit to suit an XL Charger. However, he points out that the wiring around other flashing units may be different.

The flasher unit remains on but not earthed until the switch selects the bulbs, which are earthed, providing the pulsing action. It was not practical to connect the buzzer directly from point A as it would sound all the time while driving, and the switch/bulb wiring was too far up in the instrument panel.

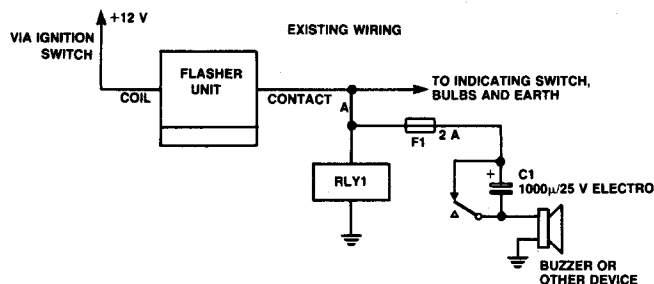
The relay will pull in when the ignition is switched on and the capacitor will discharge momentarily sounding the buzzer and

then ceasing. When the indicating switch is selected, the relay will click on and off in conjunction with the flasher. C1 will discharge, sounding the buzzer quickly. It then stops while C1 charges up again.

When the indicators stop, the capacitor once more discharges and the buzzer fades until switched on again. The 2 A fuse protects the contacts but if a larger relay was used the fuse could be left out. An on/off switch could be fitted at point A or the negative terminal of C1.

The entire unit was small enough to be housed in a Strep-sil tin and placed behind the dash on a small ledge.

If it goes off when it shouldn't, it indicates faulty wiring or an incorrect earth.



Pseudo zener

THE CIRCUIT CONSISTS of a transistor Q1 which dissipates most of the power and a zener diode ZD1 which supplies a reference voltage. When the voltage on the collector is greater than the total voltage across the zener and the transistor's base-emitter, Q1 will start to conduct, lowering the voltage on the collector. The circuit will reach a point of equilibrium where only enough current flows into the base of Q1 via ZD1 to maintain the collector-emitter voltage.

A zener diode is usually operated reverse biased i.e. positive is applied to the cathode. However, when it is forward biased it will conduct with only less than one volt (approximately 0.65 V depending on the current) across it. To simulate this in the artificial zener a diode D1 can be used although in most applications this is not necessary.

Transistor Q1 still has to dissipate the power that would otherwise be dissipated in an expensive zener. There is no way of avoiding this dissipation and it should be remembered when heatsinking Q1.

Table 1 enables you to select the transistor type depending on the zener diode that you require. Information is given as to whether or not the transistor needs to be heatsinked. If Q1 does require heatsinking the maximum temperature of the mounting base is given; if Q1 does not need to be heatsinked then the maximum ambient operating temperature is stated.

As an example, a pseudo zener of 33 V at 400 mA is required (33 V is part of the standard zener ranges). If you look down the 40 V column (the lowest voltage in the table above the voltage required) and across the 500 mA row (the lowest current above the 400 mA required) you will find that you need a 2N3055 transistor heatsinked and with a mounting base temperature that is less than 170°C. The zener diode that is used as a reference needs to have a voltage rating of 32.35 V.

$$\begin{aligned} \text{ZD1} &= \text{V1} - 0.65 \text{ from table} \\ \therefore \text{ZD1} &= 33 - 0.65 \\ \therefore \text{ZD1} &= 32.35 \text{ V} \end{aligned}$$

The nearest zener diode easily available has a voltage rating of 33 V which gives a nominal V1 of 33.65 V and a maximum of 33.8 V.

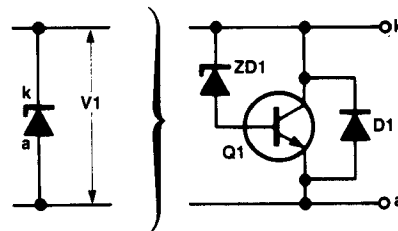
$$\begin{aligned} \text{V1 (max.)} &= \text{ZD1} + 0.8 \text{ V from table} \\ \therefore \text{V1 (max.)} &= 33 \text{ V} + 0.8 \text{ V} \end{aligned}$$

This excludes the tolerance of the zener diode and assumes the transistor is at 25°C. The temperature coefficient of the transistor is approximately -2 mV/°C.

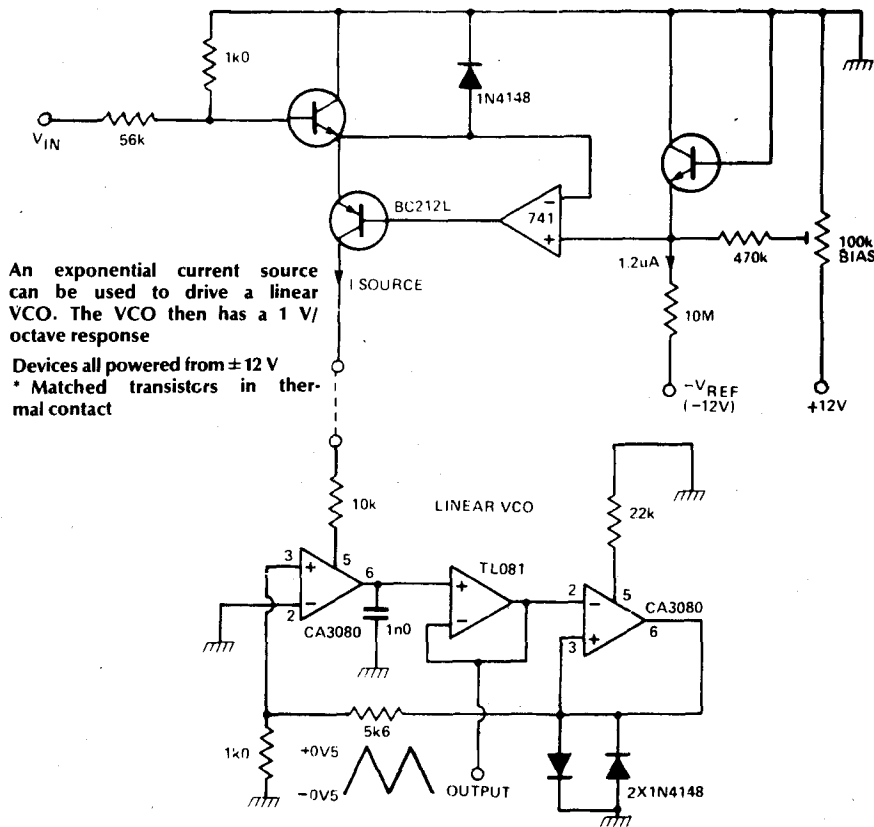
The 33.8 V maximum voltage is a pessimistic rating and should be less; 0.8 V in 33 V is only one part in 42 anyway.

	8 V	16 V	40 V	
Transistor	BD137	BD137	BD137	
Heatsink	no	no	no	
Max. temp.	50°C	50°C	50°C	25 mA
	$\text{ZD1} = \text{V1} - 0.65$ $\text{V1} < \text{ZD1} + 0.80$	$\text{ZD1} = \text{V1} - 0.65$ $\text{V1} = \text{ZD1} + 0.80$	$\text{ZD1} = \text{V1} - 0.65$ $\text{V1} = \text{ZD1} + 0.80$	
Transistor	BD137	BD137	BD137	
Heatsink	no	no	yes	
Max. temp.	50°C	50°C	110°C	50 mA
	$\text{ZD1} = \text{V1} - 0.67$ $\text{V1} < \text{ZD1} + 0.84$	$\text{ZD1} = \text{V1} - 0.67$ $\text{V1} < \text{ZD1} + 0.84$	$\text{ZD1} = \text{V1} - 0.67$ $\text{V1} < \text{ZD1} + 0.84$	
Transistor	BD137	BD137	BD137	
Heatsink	no	yes	yes	
Max. temp.	50°C	110°C	110°C	100 mA
	$\text{ZD1} = \text{V1} - 0.77$ $\text{V1} < \text{ZD1} + 0.88$	$\text{ZD1} = \text{V1} - 0.77$ $\text{V1} < \text{ZD1} + 0.88$	$\text{ZD1} = \text{V1} - 0.77$ $\text{V1} < \text{ZD1} + 0.88$	
Transistor	BD137	BD137	2N3055	
Heatsink	yes	yes	yes	
Max. temp.	110°C	110°C	188°C	200 mA
	$\text{ZD1} = \text{V1} - 0.73$ $\text{V1} < \text{ZD1} + 0.90$	$\text{ZD1} = \text{V1} - 0.73$ $\text{V1} < \text{ZD1} + 0.90$	$\text{ZD1} = \text{V1} - 0.65$ $\text{V1} < \text{ZD1} + 0.68$ 1 watt zener	
Transistor	BD137	2N3055	2N3055	
Heatsink	yes	yes	yes	
Max. temp.	110°C	188°C	170°C	500 mA
	$\text{ZD1} = \text{V1} - 0.81$ $\text{V1} < \text{ZD1} + 1.00$	$\text{ZD1} = \text{V1} - 0.65$ $\text{V1} < \text{ZD1} + 0.80$	$\text{ZD1} = \text{V1} - 0.65$ $\text{V1} < \text{ZD1} + 0.80$ 1 watt zener	
Transistor	2N3055	2N3055		
Heatsink	yes	yes		
Max. temp.	188°C	170°C		1 A
	$\text{ZD1} = \text{V1} - 0.70$ $\text{V1} < \text{ZD1} + 1.00$ 1 watt zener	$\text{ZD1} = \text{V1} - 0.70$ $\text{V1} < \text{ZD1} + 1.00$ 1 watt zener		
Transistor	2N3055			
Heatsink	yes			
Max. temp.	170°C			2 A
	$\text{ZD1} = \text{V1} - 0.80$ $\text{V1} < \text{ZD1} + 1.30$ 1 watt zener			

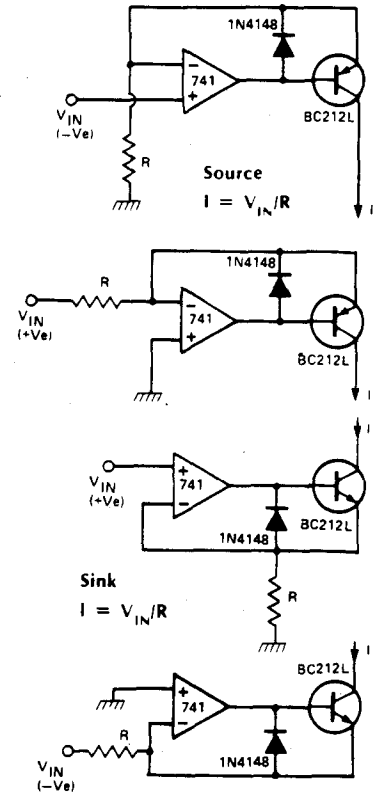
Table 1. Pseudo-zener cross-referenced with the required transistor. Unless stated the zeners are rated at 400 mW.



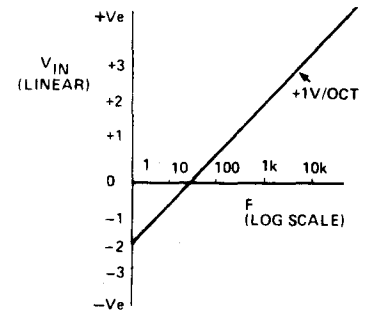
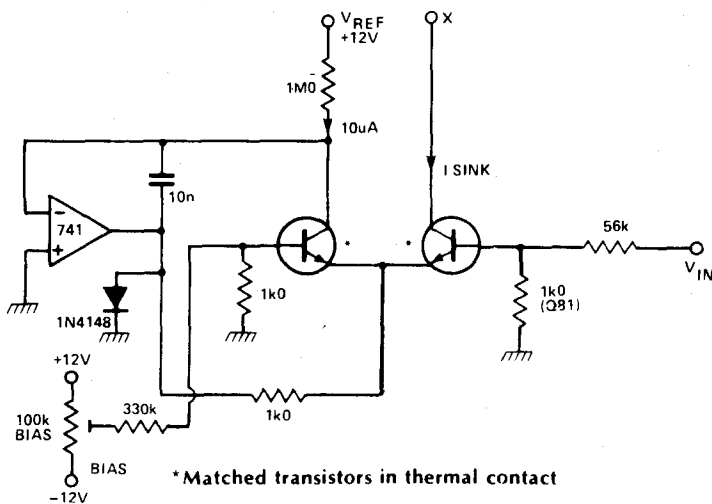
Exponential current source



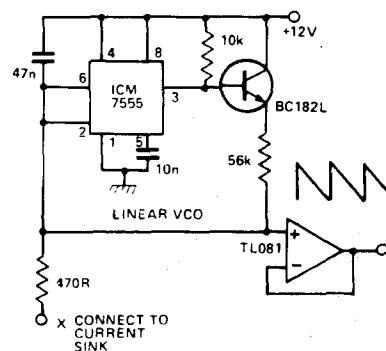
Voltage-to-current converters



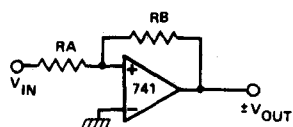
Exponential current sink



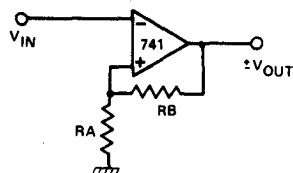
Frequency response of a linear VCO driven by an exponential current sink



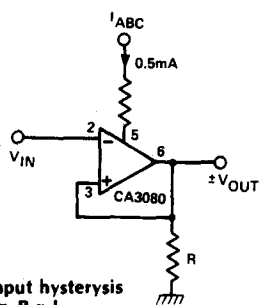
Schmitt triggers



Non-inverting; input hysteresis levels = $\pm(RA/RB) \times V_{OUT}$



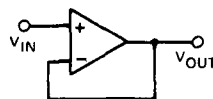
Inverting; input hysteresis levels = $\pm(RA/(RA + RB)) \times V_{OUT}$
Note that V_{OUT} depends on the supply voltage and the individual op-amp



Transconductance type; input hysteresis levels = $\pm V_{OUT}$; $V_{OUT} = R \times I_{ABC}$
R can be replaced by two 1N4148 diodes back-to-back

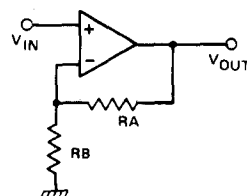
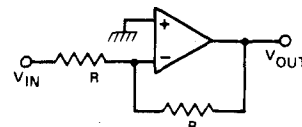
When trying to convert a slowly changing voltage into a step function with a well-defined leading edge a good Schmitt trigger is invaluable. This is a simple but effective trigger capable of good results in the audio passband. Once again, for higher frequency use substitute a faster op-amp for the 741. The Schmitt trigger works by using positive feedback to establish a 'deadband', a range of input voltages within which the output state will not change. The input voltage must exceed the higher limit in order to force the output high. Similarly, the input voltage must be taken below the lower limit to force the output low. The extent of this deadband is given in the equations.

Basic op-amp building blocks



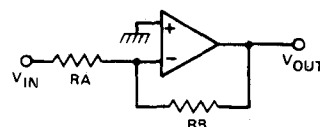
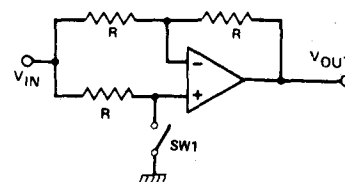
Voltage follower/buffer
Input must have a DC path to ground

Inverter
Voltage gain = -1
input impedance = R



Non-inverting amplifier
Input must have a DC path to ground
Voltage gain = $(RA + RB)/R_P$

Inverter/non-inverter amplifier
Voltage gain = +1 with SW1 open
Voltage gain = -1 with SW1 closed



Inverting Amplifier
Voltage gain = $-RB/RA$
Input impedance = RA

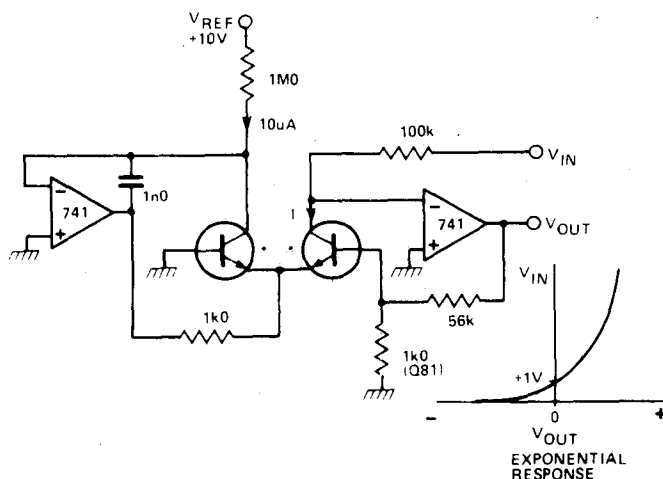
The power supply and compensation are omitted from these diagrams. If internally compensated devices are used no additional compensation is necessary, i.e: 741, TL071, TL072, TL074, etc. If additional compensation is required consult the data sheets on the particular device used.

Antilog (exponential) converter

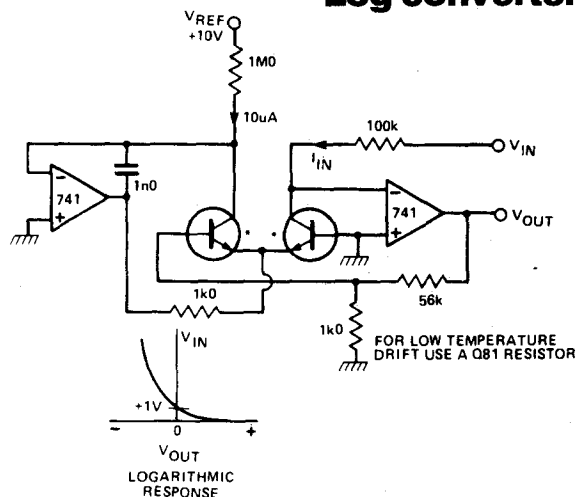
$$V_{OUT} = I \times 100k$$

The current I doubles for every 1 V increase of V_{IN}

When $V_{IN} = 0$ V, $I = 10 \mu A$

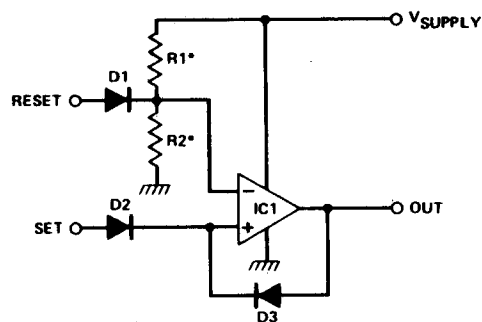


Log converter



V_{OUT} changes by 1 V for every octave change of the I_{IN} current

*The matched transistors can be two BC212L in thermal contact, or a dual transistor (LM394), or part of an array (CA3046)



TRUTH TABLE

SET	RESET	OUT
0	0	NC
0	1	0
1	0	1
1	1	1

NC = NO CHANGE

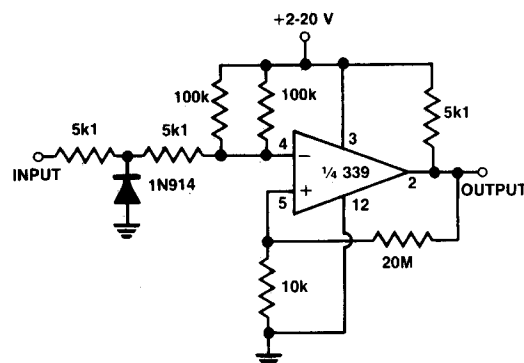
*SEE TEXT

NOTE:
IC1 IS ANY OP-AMP
D1-3 ARE 1N4148

Op-amp RS flip-flop

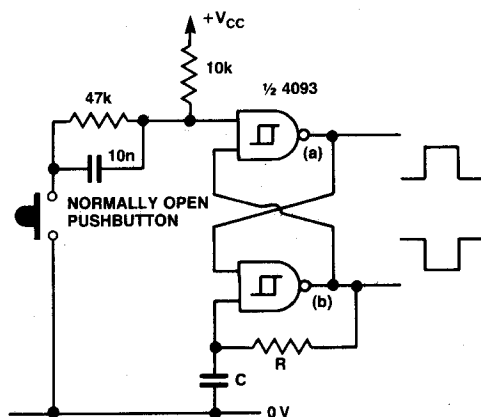
While CMOS or TTL gates are commonly used to make an RS flip-flop, op-amps can serve the same function and are often overlooked, particularly in analogue circuits where the simple RS digital function is required and using digital gates would be 'overkill'. With this circuit, you can exploit a spare op-amp from a dual or quad package. Any op-amp may be used. The high and low voltages at the output are only a function of the op-amp's internal output drive configuration.

Resistors R1 and R2 should be chosen so that $R2 = 2.4R1$ and R2 is less than V_{supply} divided by 0.05. All changes of state occur on the input low-to-high transition.



Zero-crossing detector

The output of this circuit goes high at a negative-going zero-crossing, low at a positive-going zero crossing. The input can be a sine, square or complex wave.



CMOS monostable

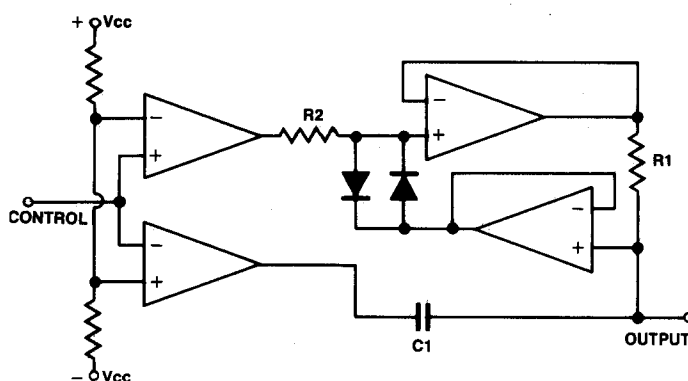
Geoff Nicholls, ETI project engineer, designed this circuit which was adapted from the familiar RS flip-flop by adding R and C.

Two gates, (a) and (b) from a 4093 quad Schmitt NAND gate, form a useful monostable multivibrator.

On power up, C ensures that the mono is in the reset state, and is charged up to the rail by R. If the pushbutton is operat-

ed, gate (a) goes high and (b) goes low. R then discharges C to the switching point when the monostable resets, thus charging C back up ready for the next period.

The recharging may be sped up by adding a diode across R, with the cathode to the capacitor side. The timing period, with $R = 1M$ and $C = 100n$, was 100 ms.



Ramp generator

R. E. Morton of Carlton NSW sent us this idea for a ramp generator.

A low voltage level on the control input causes the output to ramp down to $-V_{cc}$, while a high input causes the positive equivalent. Feeding in a square wave, of course, will yield a triangular output.

Mr Morton claims the particular advantage of his circuit is

that long time constants can be used, with the linear section of the ramp extending over almost the entire voltage range.

This happens because there is a constant current flowing out of, or into, C1. This current is constant because the voltage potential across R1 is maintained by the voltage drop across the diodes.

Resolving address contention in a microprocessor system

Picture this scene. I have just added another whatever to my processor system — a new RAM, ROM or other address space consuming device. I turn it back on and the little blighter won't reset. I turn it off, remove my new whatever and it goes like a bought one.

One possible reason? — address contentions!

These can be a real pain to find — especially when the system can't even struggle out of reset. An answer is to cycle the address bus (note one s!) and see if more than one chip select goes down at a given location — hard yakka using conventional approaches such as counters or DIP switches. Since processor chips are now so cheap there is an alternative. The steps are:

1. Obtain yourself a processor chip of your choice and resign yourself to stuffing (yes, I said stuffing) it.
2. Find out the processor's no-operation code. In the case of the 6800 it is hex 01, and 12 for the 6809. (No, I don't know what it is for the Z80 — why would I

want to when my system is 6809-based?)

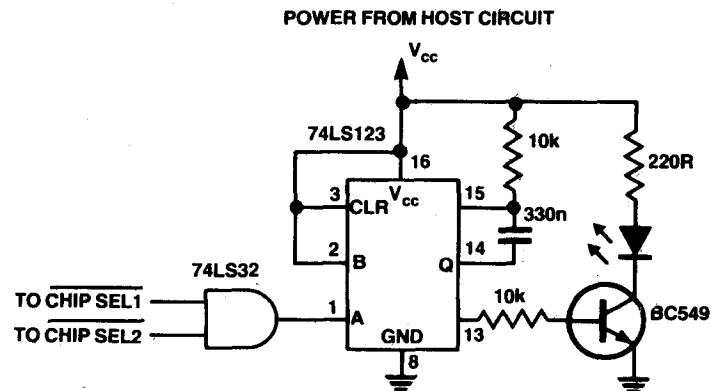
3. Put on your blue and white butcher's apron and bend all the data bus pins up!
4. Now attach the data pins which should be high for a NO-OP to the V_{cc} rail and those that should be low to the ground rail. Wire-wrap wire works well for this.

Now when your system has an address contention or other problem, this device can be used to help locate it. The use is very simple. Just power up the system with the 'modified' processor installed.

When the device resets it will read all NO-OP instructions and hence cycle the address bus through the whole address range. A logic probe or coincidence detector, like that in the accompanying circuit, can be used to detect the fault condition.

Editor's Note: For those who own Z-80 based systems, the equivalent no-operation or 'NOP' code is hex 00. Also, you don't have to butcher a CPU chip — you can use a suitably wired piggyback plug-and-socket adapter.

COINCIDENCE DETECTOR



Software selectable reverse video for the Superboard or UK101

Imagine being able to switch from white characters on a black screen to black characters on a white screen under program control, just when those alien invaders are about to demolish your last laser turret. Neil Westgarth of Modbury Heights SA could and came up with this modification.

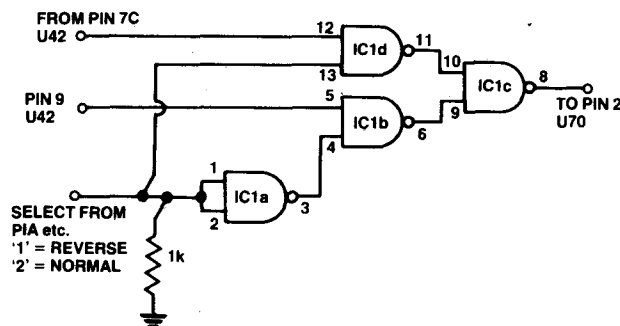
All you need is a spare half hour, a 1k resistor, a 74LS00 and a means to POKE a '1' or '0' to switch the video. In my case I use one bit of a PIA port, however if you have a bare board with no other modifications you can use pin 5 of U14 (ACIA) which is set high by POKE 61440,81 and low by POKE 61440,17. These POKEs have no effect on other operations.

As the video information to be displayed is stored in binary form, i.e. '1' = white dot and '0' = black dot, it is a simple matter to switch an inverter in

the appropriate port of the video circuitry and thereby reverse the video information.

All the modifications that I have seen to date use a DPST switch to do this and although it is effective it is a little awkward in use. I found it desirable to have it software switchable. The relevant circuit information can be found on OSI supplied circuits sheet 10 of 13.

As shown U42 is a 74LS165 shift register whose Q output is used to shift



the video information to pin 2 of U70. The modification involves cutting this connection and then selecting either pin 9 (Q op) or pin 7 (Q op, previously unused) through to pin 2 of U70 as before. The same modification is done to the UK101 except that U42 and U70 become IC42 and IC70 respectively.

The 74LS00 and resistor can be mounted on the prototyping area of the superboard. Remember to take care when cutting or soldering to the pc board traces.

Extended graphics for the Microbee

Hi-res graphics on the Microbee suffers a severe limitation due to the fact that only 128 PCG characters are available to generate the graphics display. On the normal 64 x 16 screen there are 1024 character locations. Therefore, for unrestricted graphics 1024 PCG characters would be required (for the worst case where each character location needs to be occupied by a different character).

To store data for 1024 characters requires 16K of PCG RAM. This would give complete 512 x 256 hi-res graphics. Even better graphics can be obtained by setting up the VDU in 80 x 16 (not 80 x 24) format. This gives a 25% wider screen, and hence a 25% larger display area with 640 x 256 graphics. A screen of this format has 1280 character locations, requiring 20K of PCG RAM for optimum results.

This circuit provides a method of adding this extra RAM (without detracting from the size of the main program memory). To have more than the present maximum of 256 characters available, an extra byte (or portion thereof) is required for character specification. Hence an extra RAM chip is required for the screen memory. This extra byte is used to select which of the PCG chips is used for a particular character. The extra screen RAM chip is addressed and enabled identically to the existing one. Its data outputs are, however, connected indirectly to the $\overline{CS}$ pins of the PCG RAM chips.

The PCG RAMs also have common addressing; this means that all the PCG characters will, as at present, have a lower byte code between 80H and FFH. The result of this is that the standard ASCII characters still require only one byte for their specification i.e. the chip select byte in the additional screen memory has no meaning for character codes between 0 and 7FH.

The screen memory now consists of two identically addressed RAM chips i.e. they are identically connected to the Z80 address buss, thus occupying no

more of the memory map than at present. The PCG memory now consists of 8 or 10 identically addressed RAM chips. Therefore, two data ports are necessary to select the appropriate chip for read/write. Here, port 10H is used to select the appropriate chip in the PCG bank and port 11H is used to select the appropriate chip in the screen bank (only the LSB of this port is used). The port selection is only of relevance when writing to or reading from RAM.

Port decoding of address lines A0-A7 and $\overline{IORQ}$, $\overline{MWR}$ lines is done by IC1, IC2a,b,c, IC3a and IC4a,b. The data of port 10H (the lowest four bits) is latched by IC8, which may be battery backed-up if required. The LSB of port 11H is latched by IC5.

Screen Ram

In the original setup the data pins of the RAM are connected to the Z80 data buss via tri-state bi-directional buss drivers (74LS245). When read/write is required, pin 19 of IC11 is enabled, connecting the data pins of IC5 to the data buss. The direction of the connection is controlled by the $\overline{XWR}$ line. In the modified system another 74LS245 (IC6) is used to connect the additional screen RAM (IC7) to the data buss. The data at port 11H selects which of IC6 or IC11 can be enabled by a read/write request, hence providing selection of one or the other RAM chip.

NOTE: All IC numbers in bold refer to IC numbers of existing ICs on the Microbee motherboard.

PCG RAM

In the original system, the address lines of the PCG chips are connected via two-way selectors (74LS157) to either the Z80 address buss when read/write is required or the data outputs of IC5 (existing screen RAM) and address lines generated by IC9 (VDU controller). A similar arrangement is employed in the modified design for controlling the selection of a particular chip in the PCG bank. When read/write is required, the chip selected is determined by the data at port 10H. Otherwise, the

chip selected is determined by the data outputs of IC7 (extra screen RAM). IC9, a 74LS157, is used to do the selection and its outputs are decoded by a 74LS154 4-bit binary to 16-line decoder, providing the required number of $\overline{CS}$ lines.

Since a maximum of 10 $\overline{CS}$ lines are required a 10-line decoder, such as a 74LS42, may seem a better choice. However, the 74LS42 and all of the other standard TTL 10-line decoders do not have an output disable pin. Therefore, their use in this application would require 10 additional OR gates to provide this function. Hence the choice of 74LS154, which has two output disable pins. One of these output disable pins (pin 18) is driven by the line that used to drive the $\overline{CS}$ pin of the original PCG RAM chip.

Battery back-up of port 10H

If required, IC8 can have its positive supply pin connected to the supply used for the CMOS RAM chips. If this is done, the transistor Q1 and associated components should be included. This circuitry is used to detect when the main +5 V supply falls; when this happens the output of IC8 goes into a high impedance mode, and the inputs are disabled preventing unwanted changes in the data as the main supply falls.

If this option is not required pins 1 and 10 should be connected to 0 V, and IC8 may be a 74LS173 instead of a 74C173.

I successfully used this arrangement on the ROM expansion interface published in ETI, November '83, the 'Microbee MultiPROM interface', where I substituted a 74C173 for the 74LS174 specified. The result was that ROM selection was maintained after power down. **Caution:** These two ICs are not pin compatible and should only be used to replace IC9.

Construction

All IC numbers in bold refer to IC numbers of existing ICs on the Microbee motherboard.

Join address lines $\overline{WR}$, $\overline{OE}$, $\overline{CS}$ and power lines of IC7 in parallel with those of IC5 on the Microbee. Join address lines,

data lines, $\overline{WR}$, $\overline{OE}$ and power lines of IC11 up to IC(11+n) in parallel with those of IC18 on the Microbee.

Break the line joining pin 19 of IC11 and pin 9 of IC16 on the Microbee. Break the line joining pin 18 of IC18 and pin 3 of IC16 on the Microbee.

The circuitry drawn within the box is to allow the data on the output of IC8 to be maintained by battery backup. If this is not used pins 1 and 10 of IC8 should be connected to earth.

The design of this circuit means that the number of extra PCG RAM chips used could be between one and 15. The actual number used would depend on the individual's expectations and requirements.

Use of the circuit

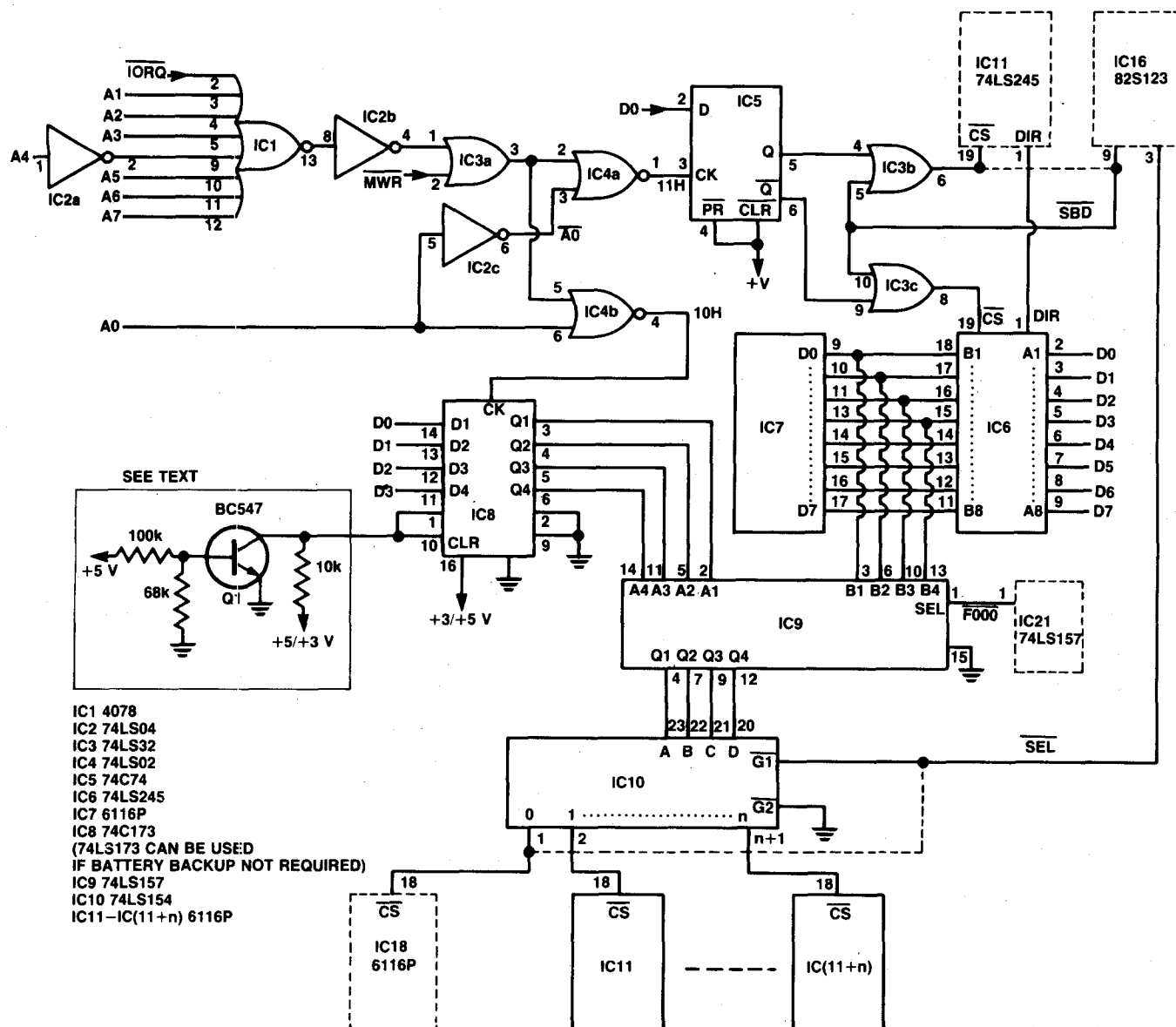
The advantages of this circuit can not be fully realised from the existing BASIC graphics routines. The present graphics commands will still work (the same as they used to) provided that the value at port 10H is the same as the value stored in all the locations of the extra screen RAM chip.

To achieve the unrestricted graphics, however, machine code routines will be required (which could be called from BASIC) to cover all the required graphics commands. You might even like to modify the existing graphics routines, or insert a call from the existing routines to routines located in an EPROM somewhere.

Extra Benefits

With this circuit space exists for eight or ten different character sets which could be used simultaneously e.g. PCG 0 could be loaded with inverse characters while PCG 1 is loaded with underlined characters, and the others could have characters with different typefaces e.g. DATA 70 as shown on page 61 of ETI, January '84.

The particular type of character displayed at a particular location would depend entirely on the byte stored in the extra screen RAM. If the graphics facilities were not being used the extra PCG memory could be used for data storage. It is also possible to locate short machine code routines in this RAM.



Routines

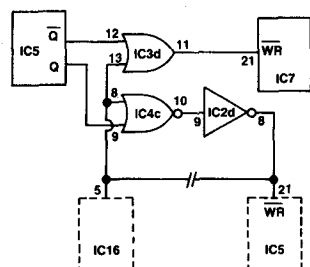
These routines can be used to set up the 80 x 16 format.

1. Using the CRTC table used by BASIC

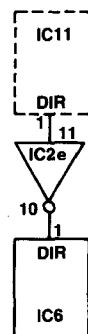
```
LD A,59H
LD (0D3H),A
LD A,50H
LD (0D4H),A
CALL 85A7H
```

```
2.
LD A,3
OUT (0CH),A
LD A,59H
OUT (0DH),A
LD A,1
OUT (0CH),A
LD A,50H
OUT (0DH),A
```

ERRATA

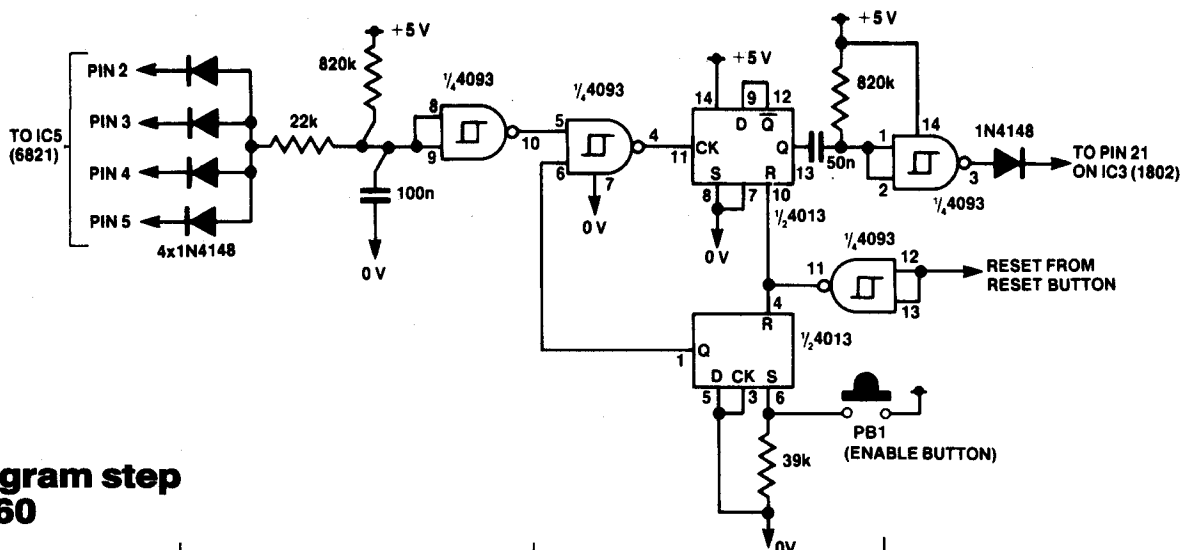


Notice that the WR lines of IC7 and IC5 should not be joined, but should be connected as shown.



There is also an error in the program listing that accompanied the article. These should read:

- ```
LD A, 50H
LD (0D3H), A
LD A, 59 H
LD (0D4H), A
LD HL, 0E1 H
CALL 85A7 H
```
- ```
LD A, 2
OUT (0CH), A
LD A, 59 H
OUT (0DH), A
LD A, 1
OUT (0CH), A
LD A, 50 H
OUT (0DH), A
```



Auto program step for the 660

This circuit eliminates the need to press the step key on the ETI-660 when you want to advance the address when you're programming it.

The annoying problem of contact bounce in the step key, which causes the computer to jump locations when programming, is also solved with this circuit.

The circuit is enabled by pressing SW1 which I set up as a

spare key on my keyboard. With the circuit enabled you then type in the program as you would normally do, however, you don't have to press the step button after every second hex digit as this is done automatically.

When you have finished typing in the program press the reset button to disable the circuit. If a mistake is made the correction procedure is the same except the

enable key must be pressed again, after correcting the mistake, to continue programming.

The step key operates normally when this circuit is enabled or disabled so you can still skip locations with it when programming.

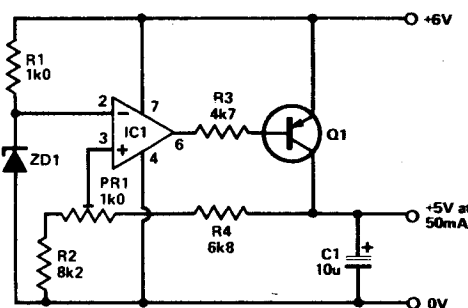
When building up the circuit change the value of the capacitor across the reset button from 100n to 200n.

Battery back-up supply for RAM

Using a rechargeable 6 V lead acid battery and the voltage control circuit shown here, data can be held in a memory for a considerable length of time (governed only by the storage capacity of the battery). Nicads have

a comparatively small Amp-hour rating for their package size and recharge rate.

An IC regulator would find the 1 V voltage margin between input and output too small for reliable operation. In this circuit the 741 op-amp sees a fixed 2V7 on its inverting input and subtracts the difference between this and the non-inverting input from its output. The ratio, once set by the preset, remains constant.



NOTE:
IC1 IS 741
Q1 IS 8CY70
or BC178
ZD1 IS 2V7 400mW
ZENER

Rapid step-through of 660 memory

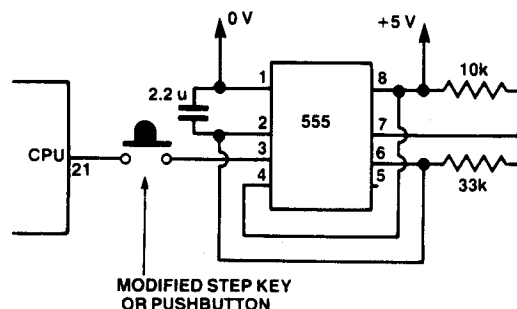
Operating the '660 by repeated pressing of the step key, or changing the contents of the address window, is a tedious way of stepping through memory.

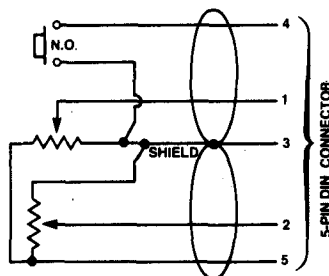
So **Michael Samerski** of **Loftus NSW** devised a circuit which uses a 555 in the astable mode to pulse pin 21 of the CPU at a pre-determined frequency, when a modified step key is pressed. This causes the '660 to rapidly step through memory.

One of the step keys can be disconnected for normal use and made to operate as a 'step repeat' key. Or a separate pushbutton may be installed.

A word of warning — never hold down both 'step' and 'step repeat' keys simultaneously as a supply short results.

A piece of Vero board was used for the circuit and glued on to the main board between IC5 and IC24.





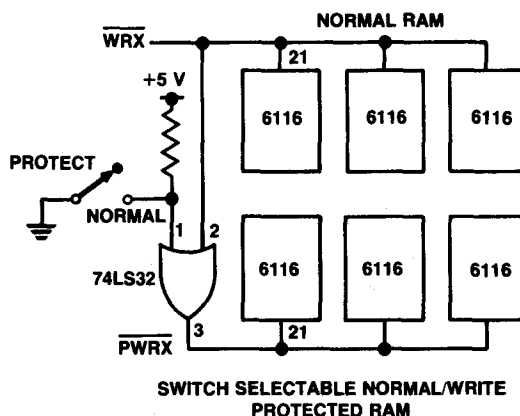
Colour computer joystick

L.W. Brown of Burwood Vic. built a pair of joysticks for his TRS80C.

I used a Dick Smith 100k pot mounted inside a small plastic box. A small pushbutton of the normally open type was used for the 'kill' control. Four core shielded cable and a wide angle five pin DIN connector were used for connection to the computer.

The one difficulty with the project is that the cover of the DIN connector fouls on the TRS80C case. The solution to this problem is to solder the two metal shells of the connector together and then glue or solder the plastic cover only partially on to this.

Microbee write-protected memory



After having inadvertently written over my source code or BASIC program with an untried program, I decided to put a copy of the program in a switch-selectable write-protected area of RAM, and then run the program.

So then if things went haywire and the source code was written over, the copy in the write-protected memory could be copied back, corrected and tried again.

To protect a 6116 the WRX line must be disconnected (pin 21) and the PWRX line connected to it. Be careful when disconnecting one line that you don't disconnect other 6116s as the WRX line is often linked from one to the next.

In the Microbee the first and last 2K blocks (6116s) should not be protected; the first is used for a BASIC-EDASM scratch pad and the last for BASIC strings and variable storage (16K and 32K versions of the Microbee).

I suggest protecting the fifth, sixth and seventh RAM chips on the 16K version, and the ninth to the fifteenth on the 32K version. (2000-37FF for 16K, 4000-77FF for 32K).

Care must be exercised with a cold start if the protected memory is selected, as the top of memory pointer will be lower than expected.

Joystick for C 64

The poor quality of the joystick supplied with the Commodore 64 caused some problems to Greg Symons of North Carlton Victoria. He replaced it with a commercial quality one which he bought from an amusement distributor for \$28.

The problem was that the new joystick needed to be rewired and mounted in a proper box so that it could be used with the Commodore. He found a box of suitable dimensions, and mounted the joystick and two fire buttons in it. He then connected some rainbow cable between the four micro switches and the joystick, the fire buttons and the computer's input port. The connections are:

Pin 1 Joy A0 Up
Pin 2 Joy A1 Down
Pin 3 Joy A2 Left
Pin 4 Joy A3 Right
Pin 6 Fire button
Pin 8 Common

Second keypad for ETI-660

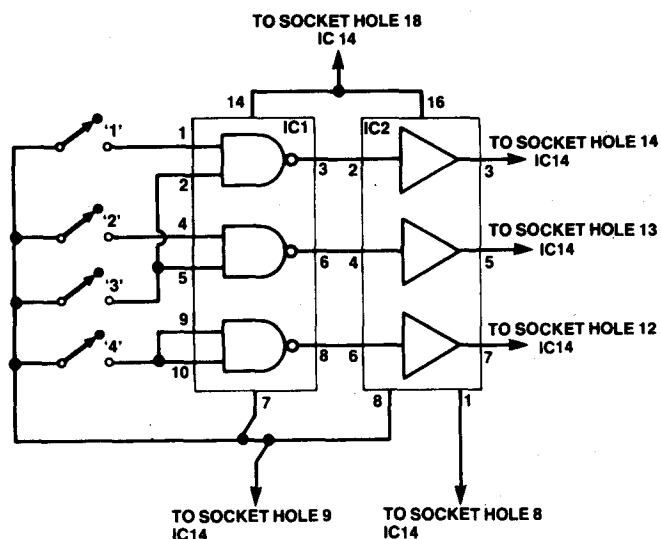
I.A. Curtis of Vale Park SA added a second keyboard to his ETI-660 computer so that he could enjoy two-player games.

This keyboard simply takes the place of RAM ICs 14 and 15, so take out ICs 14 and 15 (if they are in place) and store them in some conductive foam. Use thin solid core wire to plug in the keyboard to the socket IC14.

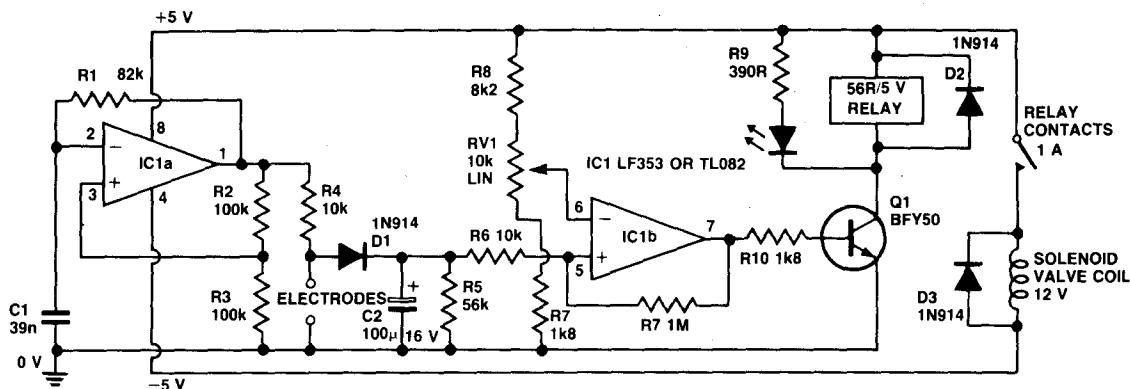
To read the value of the keyboard in a program use this program segment:

```
0600 AF00 I=0F00
0604 F165 V0:V1=MI
0604 rest of program
```

V0 and V1 now contain the value of the keyboard (lowest three bits). If no key is pressed then 0 will be returned.



Automatic watering system



An annoying characteristic of most timed watering systems is that they water in the rain, hail or sunshine.

This system for shade houses monitors the moisture level in a sample pot. When the moisture level reaches a preset trigger level the watering system is turned on.

The circuit consists of a dual FET-input op-amp in which one is wired up as a simple relaxation oscillator. The output of the oscillator is applied across a voltage divider network comprising R4 and the moisture sensing electrodes. The voltage at the top of the electrodes is rectified by D1 and smoothed by the parallel C2/R5 network. This dc voltage is fed to the non-

inverting input of the second op-amp which is operated as a comparator.

The trigger level is adjusted by RV1 and this sets the moisture level at which the system turns on.

The comparator output is buffered by Q1 which drives the relay and the 'on' indicator LED. The relay contacts operate a 12 V dc solenoid valve and are protected from arcing by D3. The solenoid valve is a 12 V dc type obtained from Goyen Controls, 152 Ipswich Rd, Woolloongabba Brisbane Qld. (07)391-4558.

The value of R4 that I have used seems to suit pots of 100-150 mm diameter using a standard commercial potting mix and

a slow-release fertiliser, 'Osmocote'. Because of the capacitance across the electrodes, a large value for R4 triangulates the oscillator waveform and lowers its peak value.

The electrodes are made from two pieces of blank copper-clad pc board with dimensions of 50 mm x 10 mm. Alternatively, the electrodes may be simply 50 mm off the ends of 7.5 A figure-8 cable which has been stripped of its insulation. As an ac voltage is applied across the electrodes corrosion is minimal. The electrodes that I use have been in a pot for at least five months with no appreciable sign of corrosion.

I placed one electrode horizontally across the bottom of the

pot — poking it through one of the drain holes. I positioned the other electrode vertically, down the side against the wall of the pot. This makes sure that the soil is moist from the top to the bottom, and not just across the top of the pot.

The plants are not adversely affected by the ac signal so it is best to use a pot containing a typical plant. Insert the electrodes, wet the soil to a reasonable degree, turn the wetness control until it just turns on and wind it back to turn it off. Put your sample pot in an average position and sit back, relax and watch it work. My plants have not looked back.

Spotlamp dimmer

If you're a hunter or a farmer and you've been out walking at night then you'll understand the problem that Alec Phillips of Myrtleford Victoria had.

I use a 12 V motorcycle battery and a 100 W spotlamp when I'm out hunting at night but it's often happened that the light starts to fade just when I'm sighting up on the last target. The battery doesn't have enough storage capacity to let me shoot that rabbit or fox, skin them, clean them and find my way home. I didn't want to carry a larger battery so I found the answer with this simple circuit which costs about \$12 to set up.

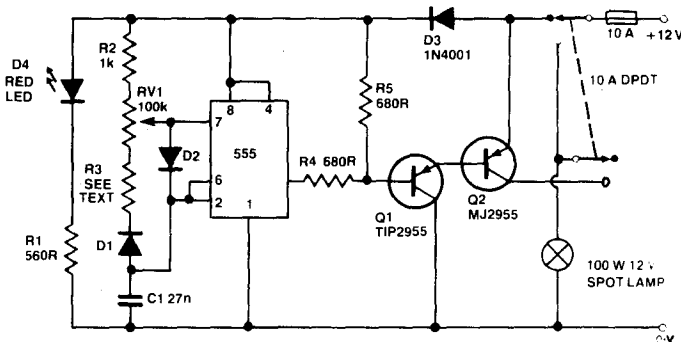
The 555 oscillator has a variable mark/space ratio by means of the 100k linear pot RV1. R4

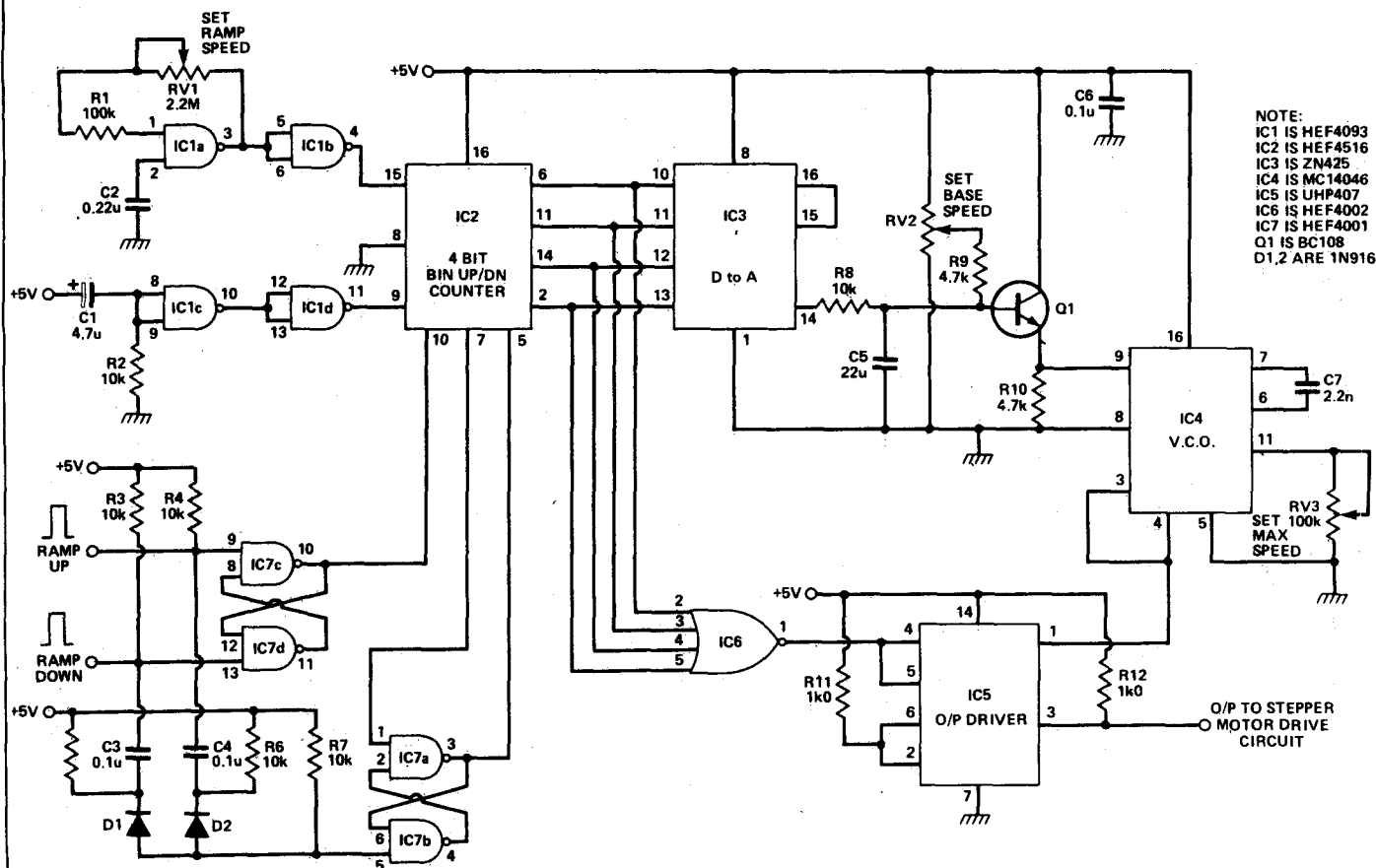
limits the load on the oscillator and the base current to Q2. D3 is for reverse battery protection of the oscillator. The DPDT switch must be rated at 10A, 12 Vdc.

Q1 and Q2 are mounted and insulated on a 10.2 mm x 7.6 mm (4" x 3") finned black aluminium heatsink which I bolted on to the circuit control box. As Q2 gets hotter than Q1 I found it best to mount Q1 at the top and Q2 at the bottom of the heatsink.

Operation is simple once R3 is chosen to suit your light requirement for walking. When the target is seen, turn the control to full on or switch to direct battery which is brightest, then the lamp may be dimmed again for walking or skinning.

Because the power to the lamp is pulsed at a high frequency the light doesn't flicker and A.H. capacity is conserved.





Ramped stepper-motor controller

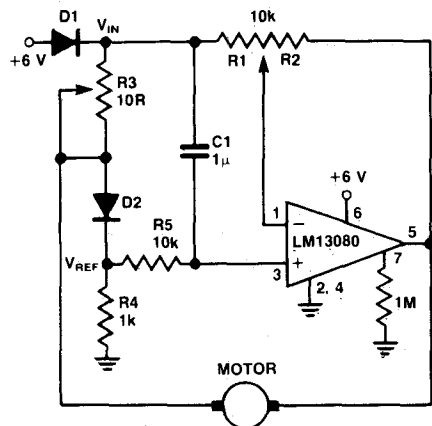
This has great applications for robotics. When the motor is at rest, the receipt of a RAMP UP pulse will cause the motor to start at its base speed then ramp up to maximum speed and run for as long as required. On receipt of the RAMP DOWN pulse, the motor will slow down to base speed then stop.

IC1a/b provides clock pulses (ramp speed) to a four-bit binary up/down counter, IC2. On receipt of the RAMP UP pulse IC7c/d sets count up and IC7a/b enables the counter. Unless a RAMP DOWN pulse is received the counter will reach its maximum count (max. speed) and hold at this until the RAMP DOWN pulse is re-

ceived. The latter will set count down and enable the counter which then counts to zero (base speed) and hold again until the next RAMP UP pulse.

The counter output drives the D-to-A converter IC3, the ramping output of this controlling the VCO, IC4. The lower frequency of the VCO (base speed) is set by the bias adjustment of Q1. Upper frequency (max. speed) is set by the 100k pot, RV3. IC5 provides open-collector drive for the output pulse train and also the on/off gate, controlled by IC6, when the counter is set to zero. IC1c/d provides a set zero pulse to IC2 to ensure that the output, at pin 3 of IC5, is off each time the generator is switched on.

Speed control for dc motor

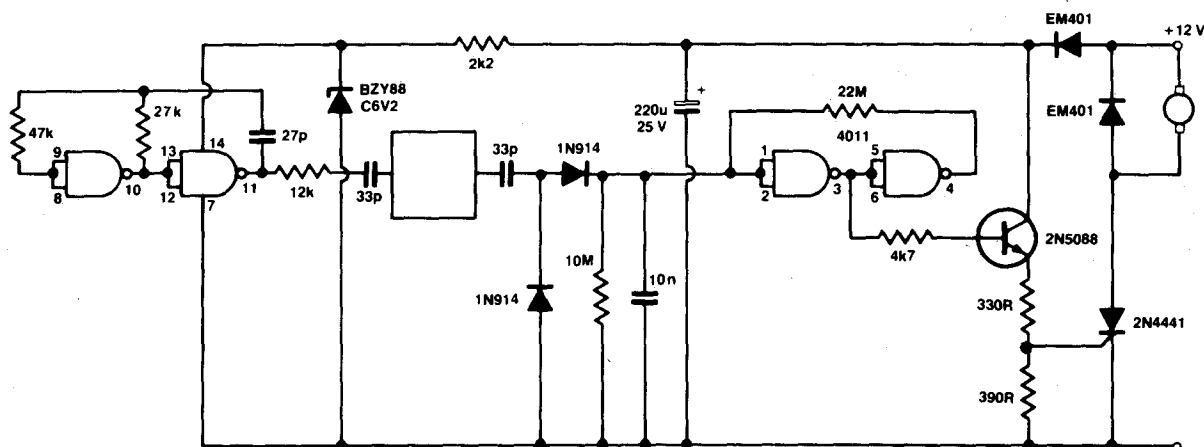


The LM13080 power op-amp is used here to provide a simple speed control for small dc motors requiring less than 0.5 A starting current. This circuit operates by impressing the multiple of a reference voltage across the motor then varying the reference by means of quasi-positive feedback to change the voltage across the motor whenever the load on the motor changes.

It works as follows: D1 brings V_{IN} within the common-mode range of the op-amp. A reference voltage is established by the combined voltage drop through the 10R pot R3 and diode D2 and is applied to the non-inverting input of the LM13080. Resistor R4 is used to bias D2 on. The 10k speed adjust pot is two resistors in one — R1/R2. R1 is the input resistance, R2 is the negative feedback resistance. Thus, the voltage impressed across the motor is given by:

$$V_{MOTOR} = \frac{(V_{BE2} + I_3 R_3) R_2}{R_1} + V_{BE}$$

The positive feedback is developed as a change in the voltage across R3 due to the change in motor current caused by a variation in the motor's load. Resistor R3 is shown as a pot so that the amount of positive feedback can be adjusted to smooth operation of the motor (no 'hunting' or 'cogging'). Capacitor C1 and R5 serve as a filter for the reference voltage. Use a polyester low voltage capacitor.



Touch motor controller

L.W. Brown of Burwood Vic. designed this circuit of a touch switch suitable for operating 12 Vdc motors. He says that an excellent use for it would be to mount the touch switch on a shop window, allowing the movement of a display via a car electric fan motor.

An oscillator drives a touch plate stuck to the inside of a glass window. Anything capacitively

grounding the 50 mm diameter touch plate causes the Schmitt trigger to turn on the SCR. The 10nF capacitor provides several seconds extra operation once the touch plate has been released. As the SCR will latch on with a dc supply, an unregulated, unfiltered supply should be used. A suitable supply would be the A&R Chargette which is double insulated and very safe.

For intermittent operation no heatsink is required and because of this the entire circuit will be smaller than the touch plate. The small size allows the whole switch to be mounted in a sealed plastic box for protection from environmental humidity. The double insulated power supply could enable the system to operate in hazardous locations.

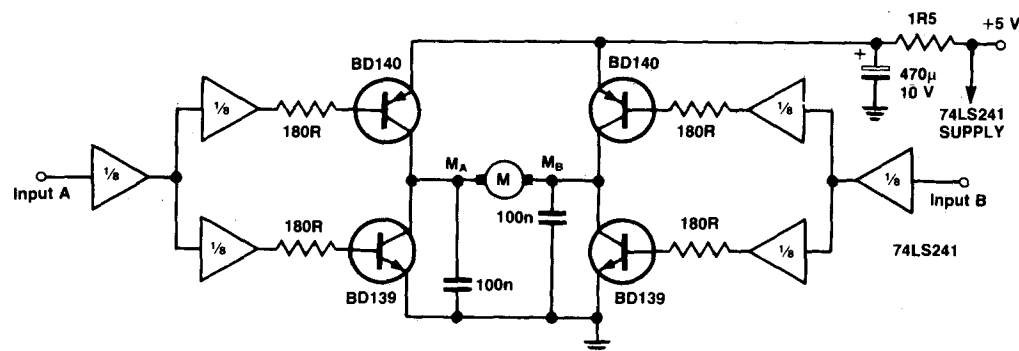
DC motor drive

This dc motor drive circuit is suitable for controlling small dc motors requiring 400 mA at six volts — such as those made by Fisher Technic.

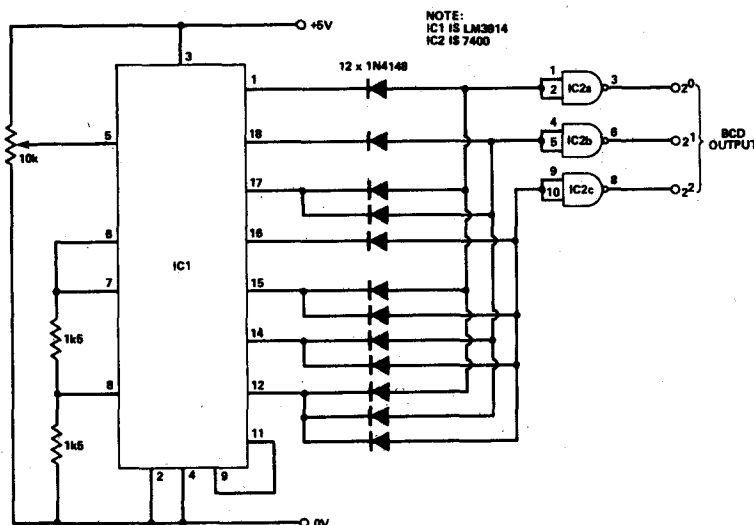
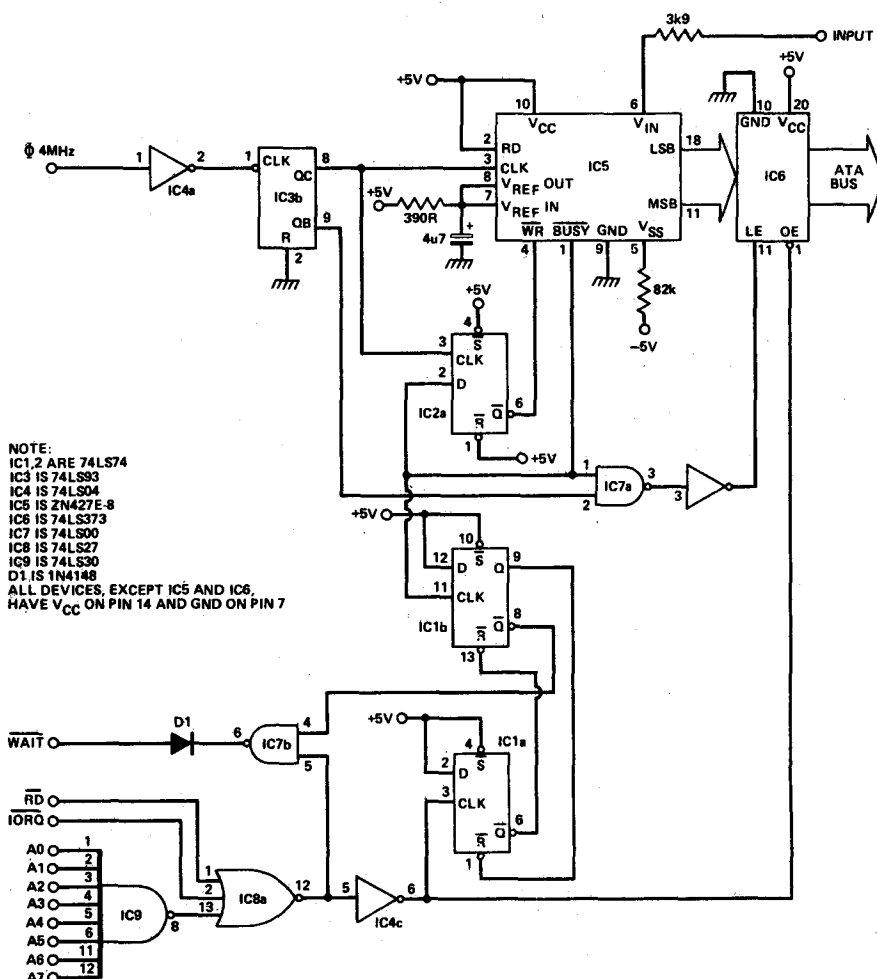
The output is a function of logic signals applied to inputs A and B, as shown in the accompanying table.

Construction is simple and little or no heatsinking is required as all transistors are either fully saturated or off.

Input A	Input B	M _A	M _B	Result
0	0	+5V	+5 V	no operation
0	1	+5 V	GND	motor turns
1	0	GND	+5 V	motor turns opposite
1	1	GND	GND	no operation

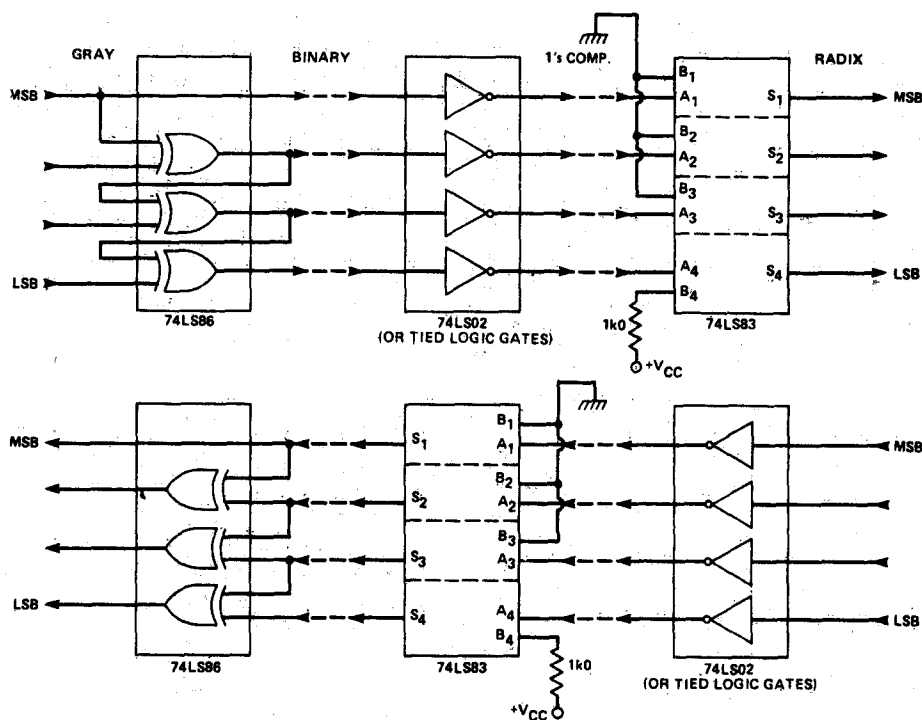


Low resolution A-to-D converter



Gray, binary and radix code manipulation

When working with encoders it is desirable to use a coding system which changes only one bit at a time — Gray code is designed for this purpose. However, for manipulation Gray code is not very convenient and has to be converted to another form; this usually being binary, one's complement or radix. The modules shown provide simple means of converting from one code to another by using standard TTL hardware. Using these circuits, code manipulation to and from any of the above conventions is possible. In many cases the speed of operation has considerable advantages over that of microprocessor software-based code conversions.



Digital audio switch

The circuit uses a CMOS 555 which oscillates at a frequency determined by the equation:

$$F = \frac{1.46}{C1(R1 + R2)}$$

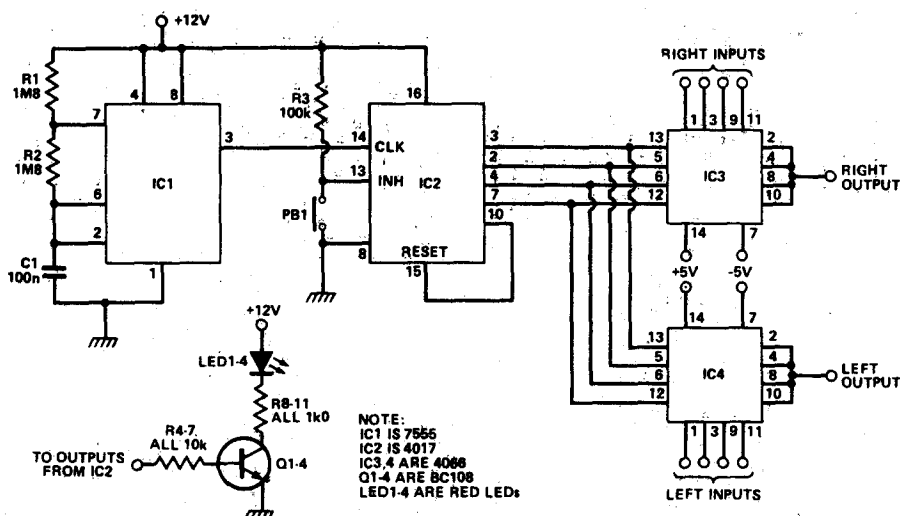
The output from IC1 is decoded by IC2, a decade counter divider, which is activated by PB1. When PB1 is pressed, IC2 produces a positive voltage at one of its four outputs, each of which controls two of the eight switches in ICs 3 and 4, and an LED circuit.

When a switch control goes high, the corresponding audio input is selected and an LED lights to indicate which input has been selected.

Output 5 on IC2 is connected to RESET so when pin 10 of IC2 goes high, the decoder resets and the next pulse from IC1 selects input A.

The chosen values for R1, R2, and C1 produce a frequency of 4 Hz, so IC2 selects each audio input and then resets in 1 second. If PB1 is kept pressed, the input will change every quarter of a second.

ICs 1 and 2 are powered from +12 V, and ICs 3 and 4 are powered from +5 V and -5 V.



Digital servo controller

This circuit uses a form of simple pulse width modulation to control a servo motor. The idea is to feed the servo a series of pulses, the operation of the servo arm being determined by the frequency and duration of the pulses.

IC1a forms an astable running at about 70 Hz. This triggers IC1c, which lengthens the pulses

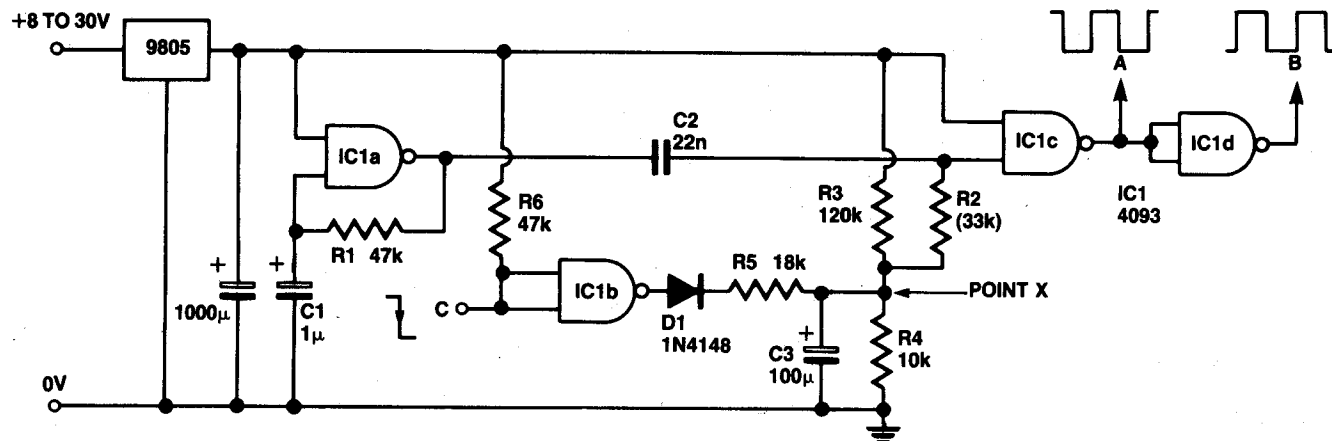
by a time determined by C2 and R2. IC1d may be fitted to invert the pulses.

The degree to which this pulse lengthening occurs is determined by the voltage at the end of R2. Initially, this is determined by the voltage divider composed of R3 and R4. This remains true so long as the diode D1 is reverse biased and R5 is

effectively open circuited. However, if the output of IC1b goes high it pulls the voltage on the divider up, so increasing the pulse width. The output of IC1b is controlled by the point C. Since IC1b forms an inverter, and since point C is normally pulled high by R6, the output is normally low. C is driven low with a mechanical switch or

some external logic.

With the values shown the pulse width varies between 0.9 ms and 1.9 ms. Most servos can be used with pulse widths between 0.7 ms and 2 ms. The pulse rate can be as high as 200 Hz and as low as 1 Hz. However, at very low frequencies the motion of the servo will probably become a little jerky.

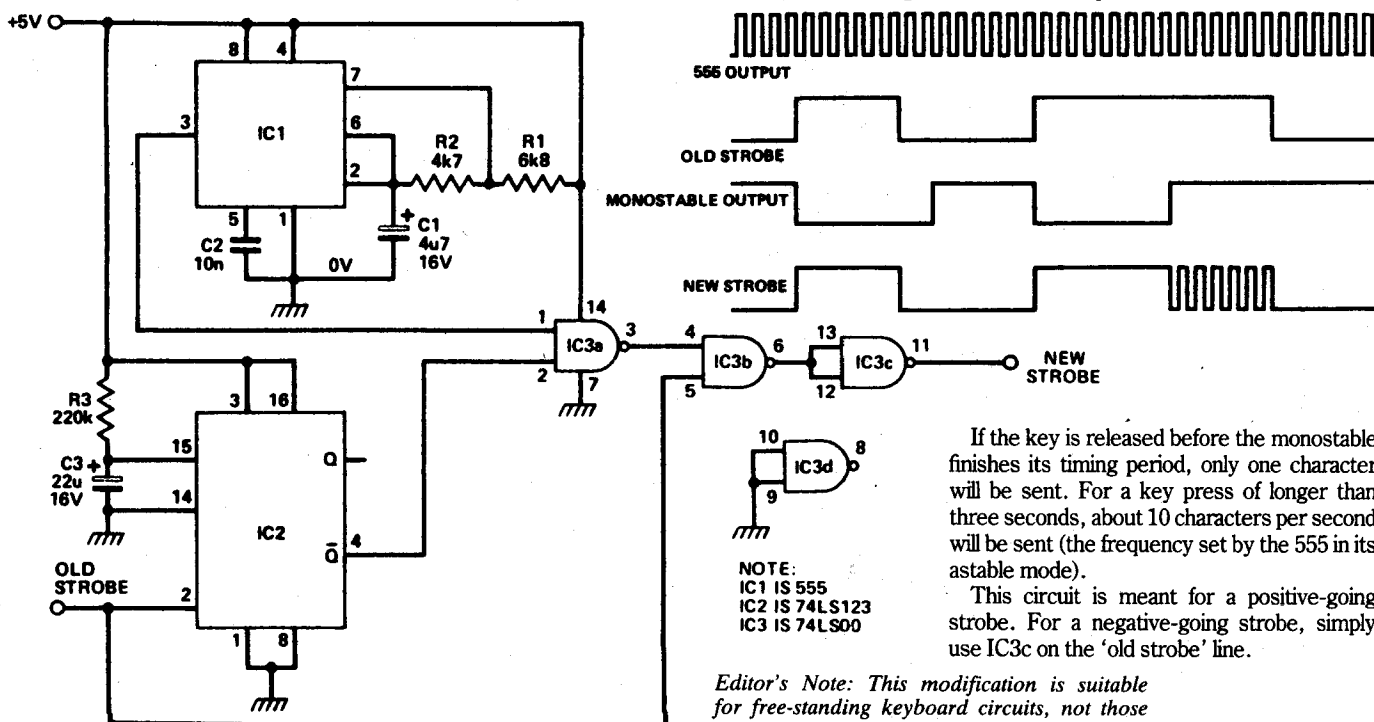


Auto-repeat for your keyboard

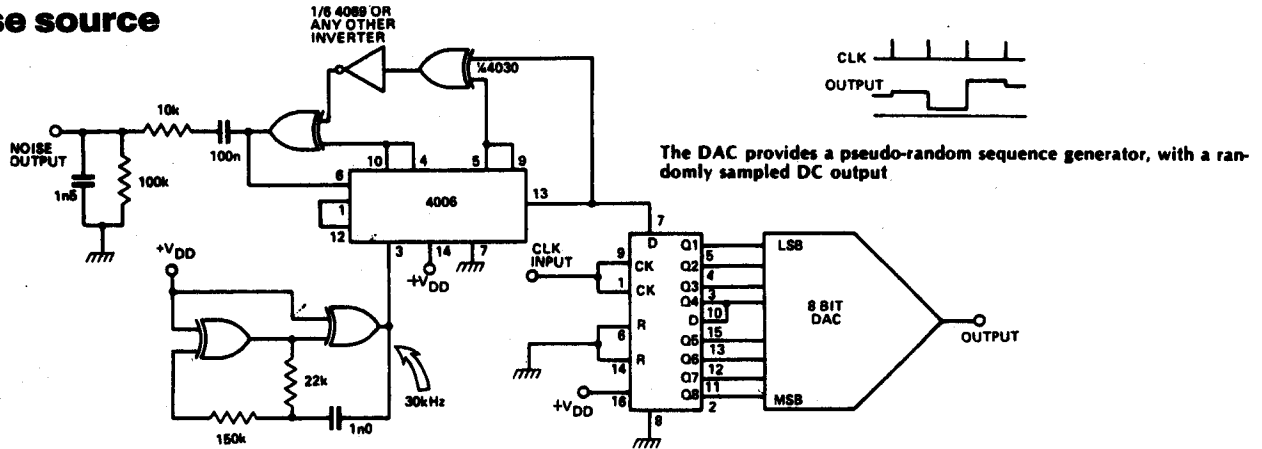
If your keyboard does not have auto-repeat, here's a solution. Just insert this circuit in the

old keyboard strobe line. Basically, the strobe line activates the monostable IC2, disabling the output of the 555, preventing its pulses reading

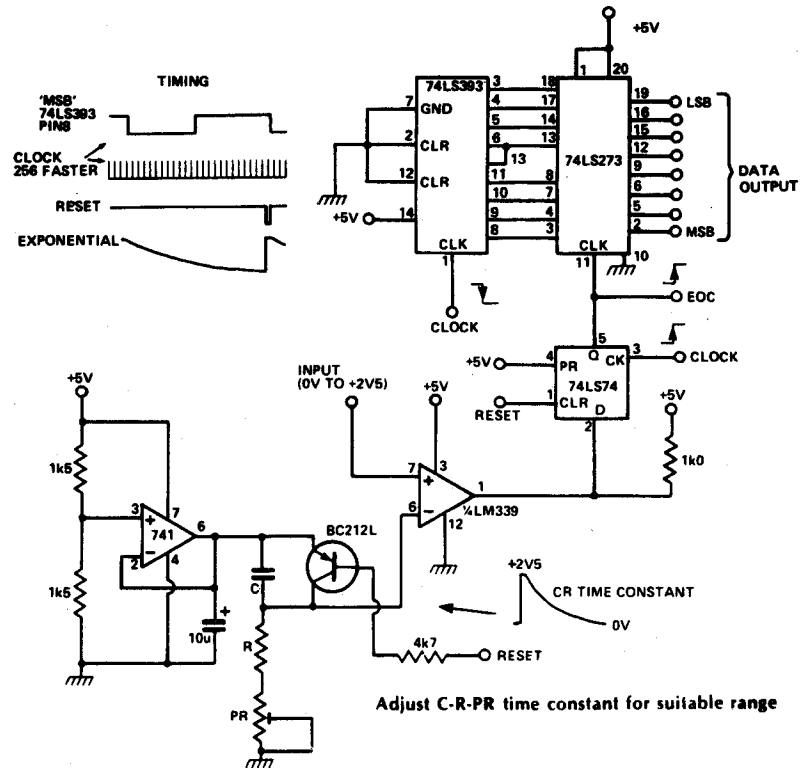
the new strobe line. After about three seconds, the output of IC2 changes state and the signal from the 555 is passed to the new 'strobe' line.



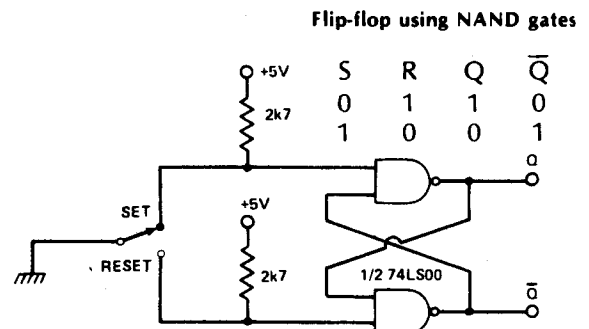
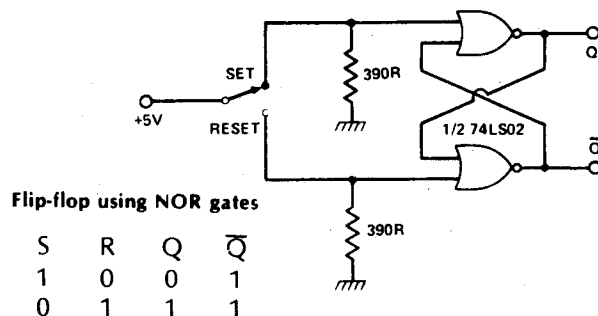
Noise source



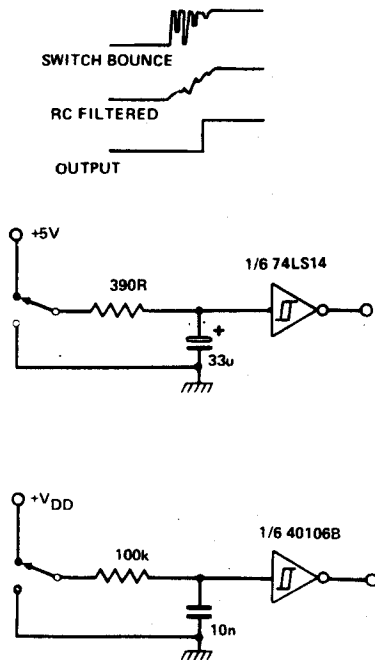
Logarithmic ADC



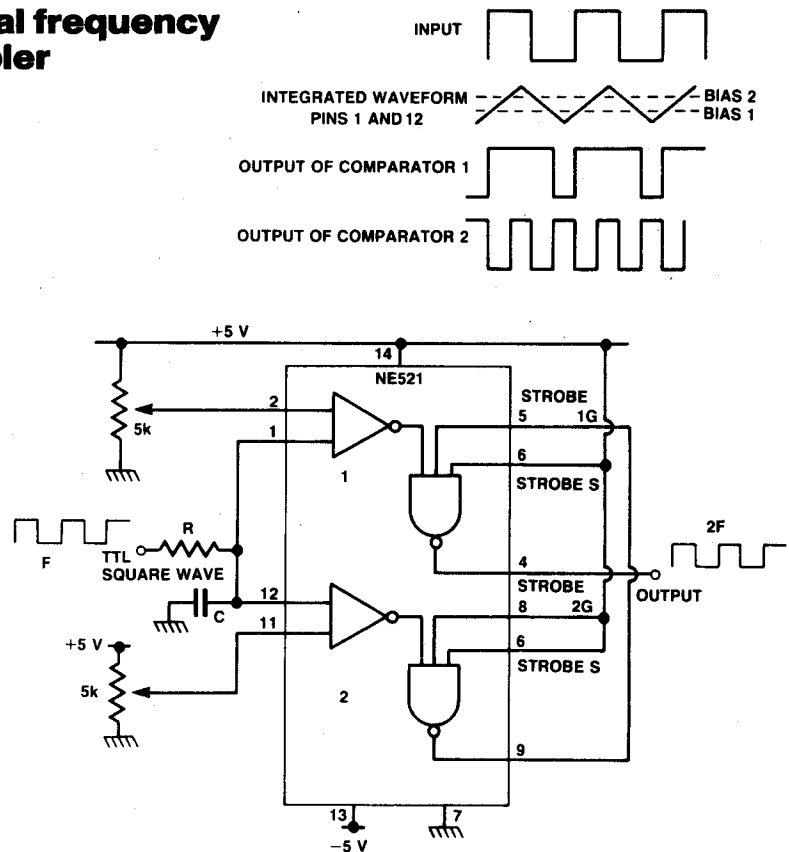
Debouncing using flip-flops



Debouncing using Schmitt triggers

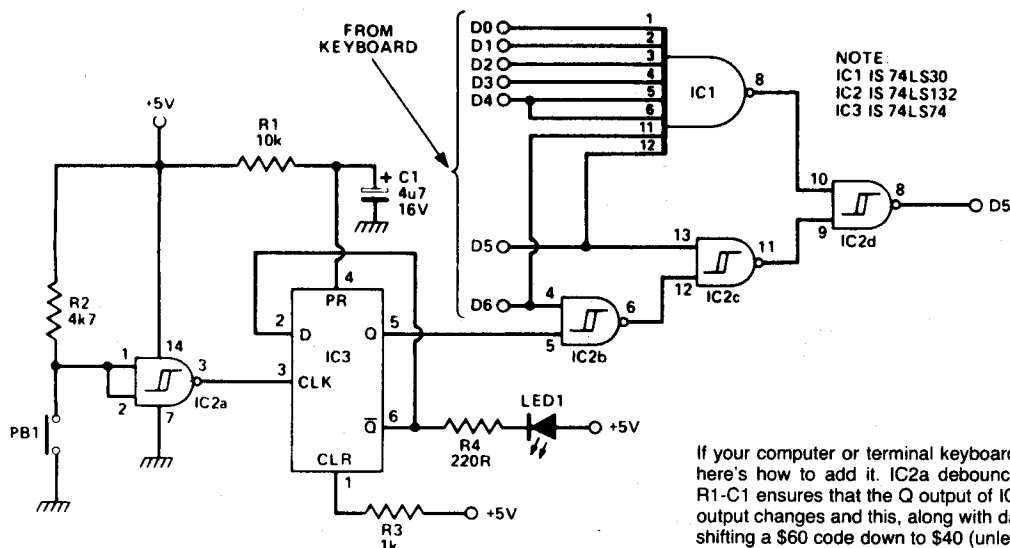


Digital frequency doubler



Digital frequency dividers are commonplace, but digital multipliers are not. This circuit employs the NE521 dual differential comparator. The input is integrated, the triangular resultant being applied to the two comparator non-inverting inputs. Setting the two 5k bias pots appropriately will provide a doubled output. This will work right up to 50 MHz with the NE521.

Alphanumeric lock for keyboard



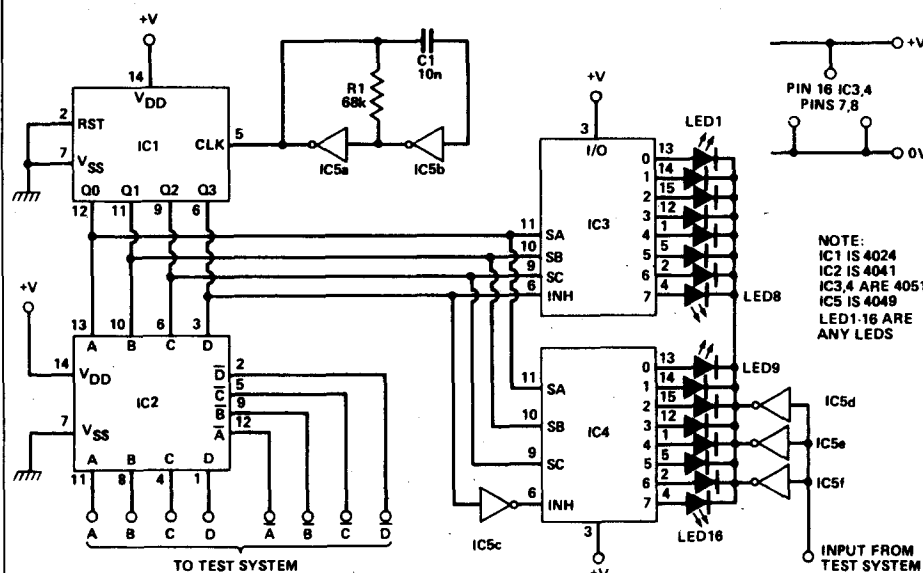
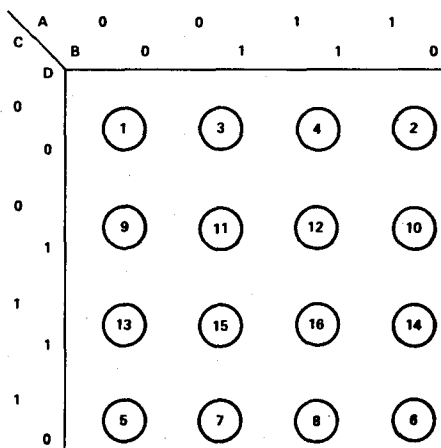
If your computer or terminal keyboard does not have an alphanumeric lock key, here's how to add it. IC2a debounces the alpha-lock key PB1. On power-up, R1-C1 ensures that the Q output of IC3 is high. Each time PB1 is pressed, the Q output changes and this, along with data bit 6 being high, will make D5 a low thus shifting a \$60 code down to \$40 (unless you pressed the DELETE key). The LED will come on to show that ALPHA mode is selected when PB1 is pressed.

To insert this into your keyboard it is only necessary for the original D5 line to pass through this circuit (D5 to D5') and add a keyswitch for PB1.

Karnaugh map display

The Karnaugh map is a common way of representing the function of a four-input logic system. It is often taught in schools and colleges, when students are given a logic system and have to draw the Karnaugh map for it. This device allows the student to go away and test their map with the actual map generated by this device and a wired-up system on a breadboard.

IC5a and b form an astable, which clocks the 4-bit binary counter IC1. The outputs of this are fed into the quad true/complements buffer, IC2, providing buffered true and inverted outputs to the system under test. The counter outputs



are also used to decode the display — the three LSBs are used as select lines for the eight-way analogue switches, IC3 and 4, and the MSB is used to select the chip by connecting the true value to INH IC3 and the inverted (by IC5c) value into INH IC4.

The output of the system is connected to the input of IC5d,e,f. Thus if the output of the system is high for a given 4-bit number, then the output of IC5d, etc., will be low, and so current will flow from the +ve supply, via the selected

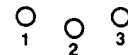
analogue switch (resistance of which is conveniently about 160R) through the appropriate LED. If the output of the system is low, then the output of IC5d, etc., will be high, and so no current will flow.

This means that an illuminated LED represents a "1" from the system, and an unlit LED a "0".

Figure 2 shows the arrangements of LED's 1-16 required to obtain the desired Karnaugh map display.

Electronic pendulum

The following circuit, from G.N. Vayro of Broadmeadows, Victoria, was used to provide a simulated pendulum effect in an electronic clock by flashing three LEDs in a particular repetitive sequence. The LEDs were arranged as follows,



and the sequence is 1, 2, 3, 2, 1.

The sequence is set for one second with the values shown and the visual effect is excellent.

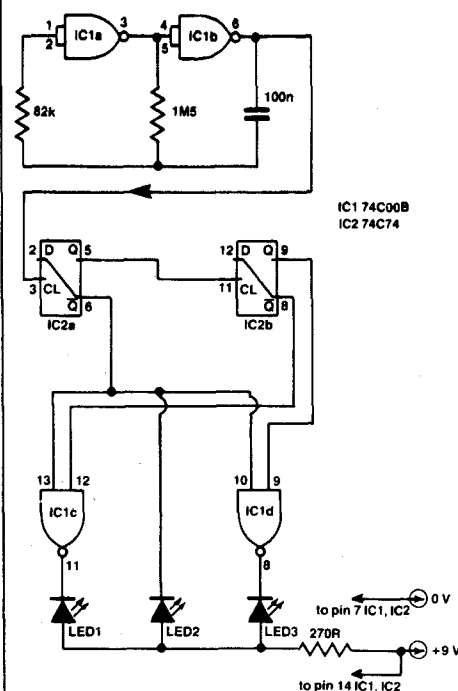
The clock is a digital modular type, mounted in a highly polished wooden cabinet, resembling the grandfather clock style, but it is only 150 mm high.

The circuit was added to my clock for aesthetic reasons and has nothing to do with the clock timing. Readers may find other uses for the circuit as it is simple and uses all gates of two ICs.

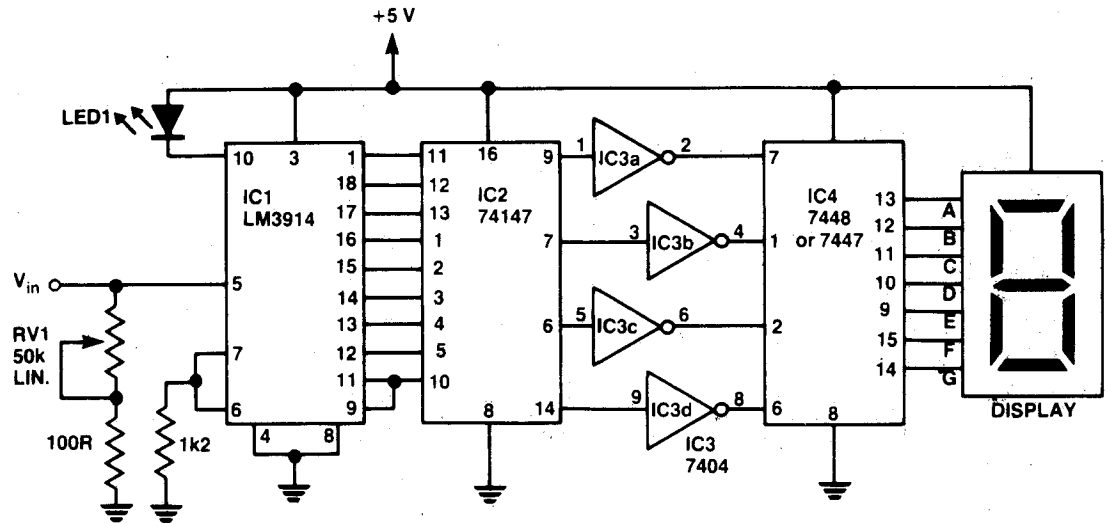
It works as follows. Two gates of the 74C00 are used as a clock driving the two D-type flip-flops, which are connected to toggle by joining the D and Q.

Frequency of operation can be changed by changing the C on the clock circuit.

The two flip-flop outputs are decoded using the remaining two 74C00 gates to provide the required effect.



Simple 'flash' type A/D converter



The LM3914 dot/bar LED driver is put to use in this circuit to form the basis of a so called 'flash' type analogue-to-digital converter. This device (IC1) will send one of its ten comparator outputs low in response to a voltage applied to its input. Which output will go low is determined by that voltage. The outputs of the LM3914 are fed to the inputs of a 9-line to 4-line BCD priority encoder (IC2), the outputs of which are inverted by IC3 and taken to the inputs of a BCD to 7-segment decoder (IC4). If a voltage is applied to the input of IC1, one of its outputs will go low (as stated before-

hand) which, in turn, sends one of IC2's inputs low and its 4-bit BCD equivalent will be set on IC2's output. This is then decoded to 7-segment format, by IC4.

Full scale deflection can be adjusted by RV1. As there are ten outputs from IC1 and only nine inputs to IC2, a LED is connected to the tenth output of IC1 and this effectively functions as an over-range indicator.

The LM3914's outputs change linearly, but if logarithmic changes are needed the LM3915 could be used. It must also be noted that for a full scale deflection of say 12 volts, each output will only

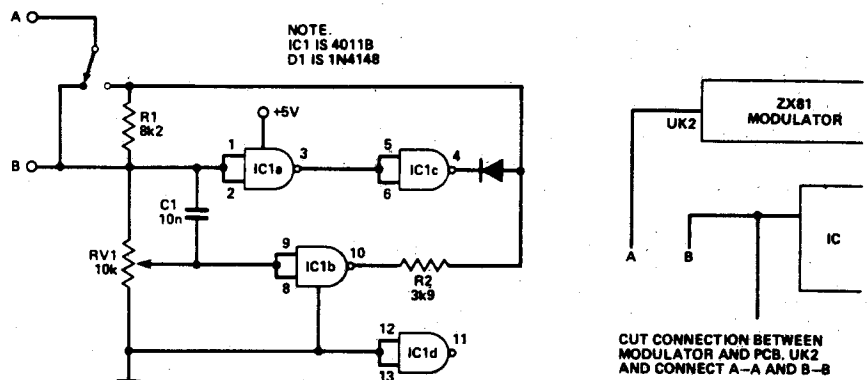
change state when the voltage on its comparator input rises at least 1.2 V above the previous comparator's threshold. (See Lab Notes, ETI March 1980 for more data.)

Despite this limitation the circuit could be used for joystick controls (two circuits per stick, leaving out IC4) for computer games, photo print meters, thermometers (where only a scale and not the exact temperature is required); in fact, anything requiring a non-critical one-digit readout from an analogue input.

ZX81 background reverse

This simple circuit uses readily available (and cheap!) components to provide white symbols on a dark background. It can be put together on a small piece of circuit board which could then be housed inside the case of the computer and held in position by double-sided tape or Araldite.

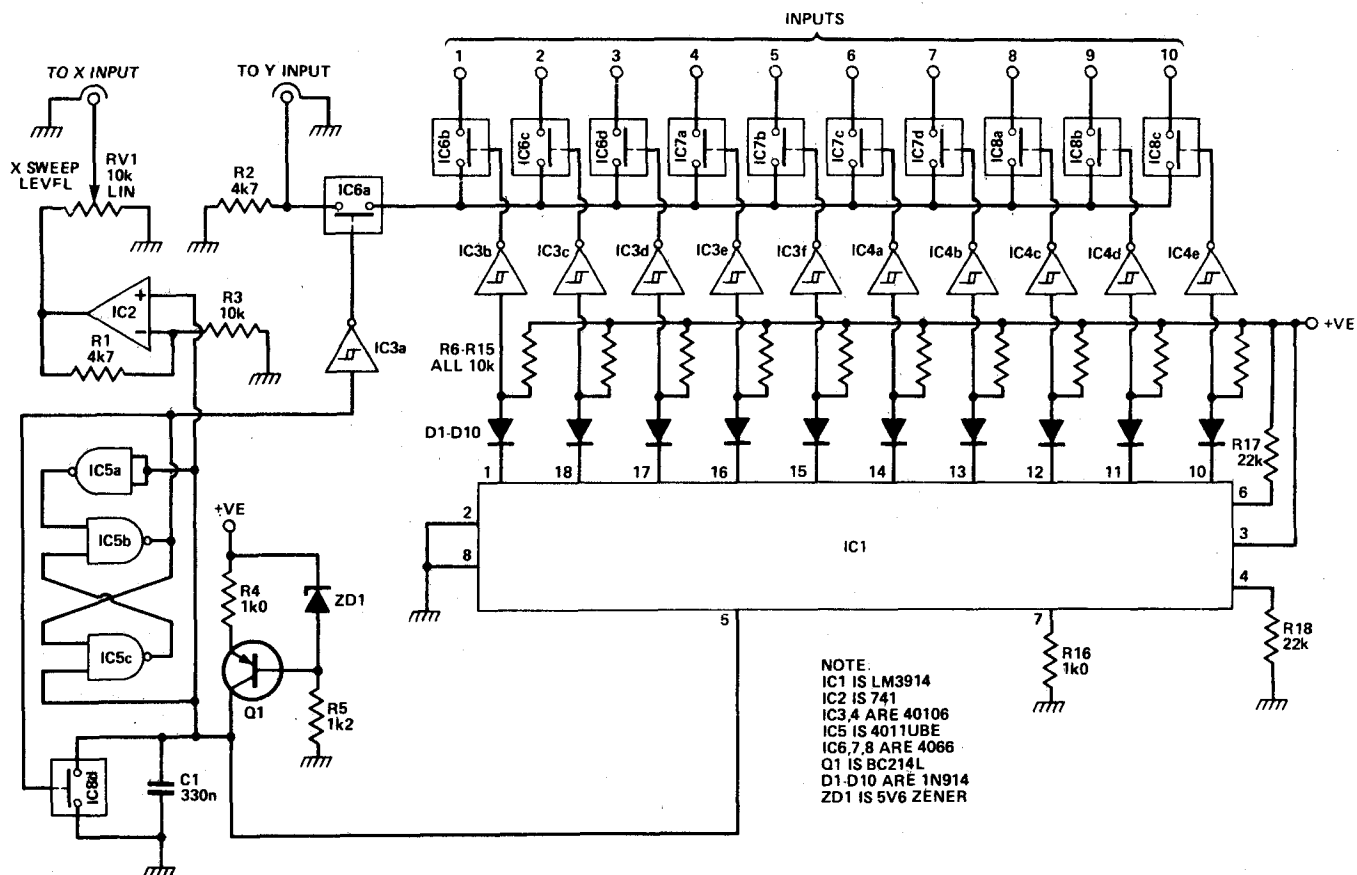
The change-over switch, used for switching from black symbols on white and vice-versa, can be mounted on the side of the case, a push-on push-off type probably being the most suitable due to ease of mounting. The power requirement is



very low, and can be taken from the ZX81 supply line.

Action of the circuit is very simple: IC1a and c carry the negative-going sync pulse and nothing else,

thus ensuring that this is not inverted. The remainder of the video signal is inverted by IC1b. The value of RV1 needs careful setting to obtain the best results.



Scope bargraph unit

This circuit is designed to be used in conjunction with any ordinary oscilloscope which has an X-deflection input, and allows it to be used as a bargraph display. The screen has 10 useable columns, thus making it suitable for use with the ETI Spectrum Analyst published recently.

The heart of the circuit is IC1, an LM3914 bargraph driver. The input to this, pin 5, is connected to a sawtooth generator running at about 1 kHz, formed around Q1. Q1 is a constant current generator supplying 5 mA and charging a 330nF capacitor to create a linear sweep. As the voltage on this capacitor reaches the upper CMOS threshold, about two-thirds supply, a latch formed by IC5b and c is triggered by IC5a. This rapidly discharges the capacitor through IC8d. When the voltage has dropped to the lower CMOS level, about one-third supply, the latch is reset and the capacitor starts to charge up again. Thus a linear sawtooth waveform is produced.

This is buffered by IC2 and fed out to drive the X amplifier in the scope. However, as this sweep also drives a bargraph IC which has its upper and lower

limits set to be similar to the two CMOS switching levels, the 10 outputs go low, one at a time, in sequence. These outputs are used to drive a multiplexing system: a set of 10 analogue switches (IC6b to IC8c). These are driven via inverting Schmitt triggers, diodes and pull-up resistors due to the limited drive capability of IC1 at logic 1.

The multiplexed output is sent to the scope's Y input via another analogue switch, which is normally on, but cut off while the sweep capacitor discharges so as to blank out the 'flyback'. Alternatively, the 'Z modulation' input of the scope could be used if one is available.

In use, the internal sweep generator in the scope is turned off and the circuit is connected. It is recommended that a regulated supply of 15 V is used so as to provide adequate X output drive. The X sweep level is adjusted until a suitable width of display is produced (this being a horizontal line at the present), which should be moved to the bottom of the screen. Now the inputs to the scope may be connected and the Y sensitivity of the scope adjusted to give a good display.

Two mode light show

This light show circuit was designed by A. Taylor of Glen Forrest, WA. It has two modes — chaser and pulser.

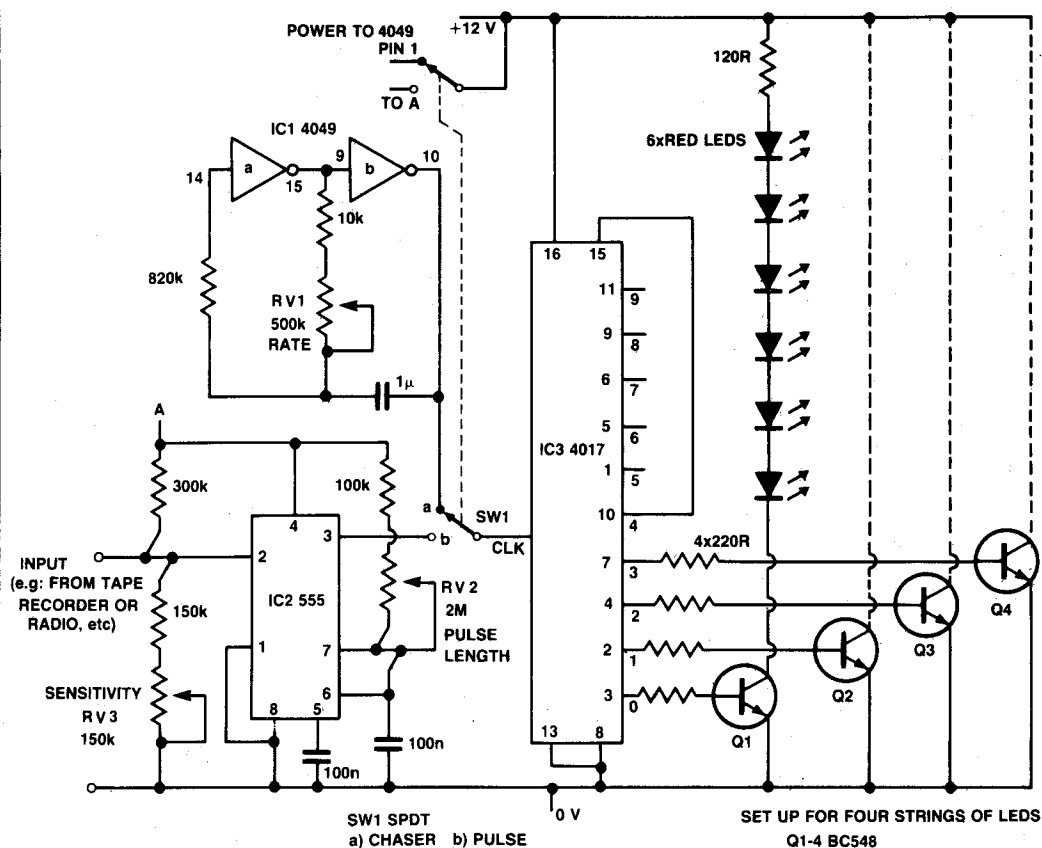
In the first mode, two inverters are set up as an oscillator with a frequency which varies from about 3 Hz to 300 Hz (adjustable by VR1). This clocks a 4017 and flashes the LEDs in sequence; if set up in a line or a circle they appear to chase each other.

In the 'pulse' mode a 555 timer is used to provide an output pulse whenever the input goes above 0.5 V. The input could be an audio signal or an output from a solar cell; it could be used to respond to other flashing lights like this.

The sensitivity control VR3 sets the voltage which the input must exceed in order to trigger the device. VR2 sets the length of the output pulse and hence sets the number of pulses that the circuit can respond to in a given period. It cannot trigger again until pin 3 has gone low. By adjusting this control a variety of different effects can be obtained.

Up to 10 LED strings can be used off the 4017. One pin, the next highest in the sequence, must go to reset, unless all 10 output pins are used, to prevent an annoying pause in the sequence.

With a 12 volt supply up to six

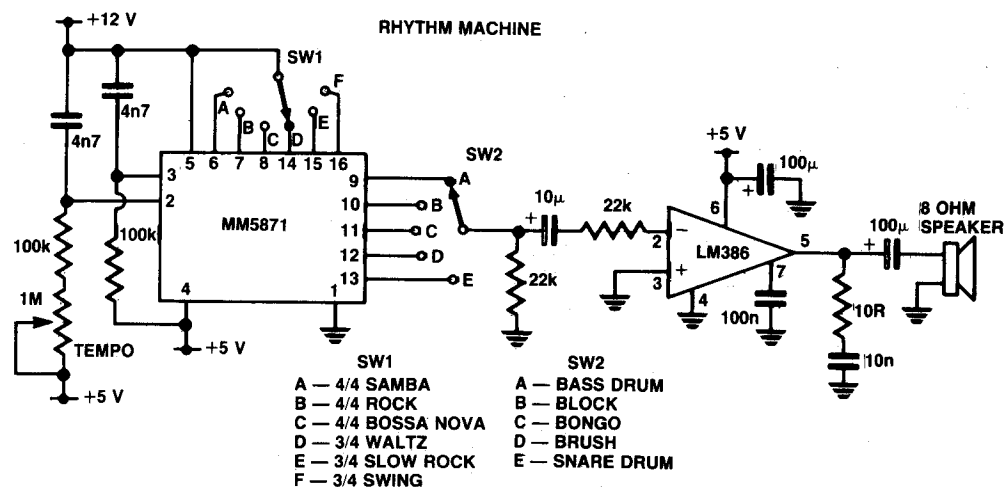


LEDs (1.6 V drop each) can be used per transistor unless two strings of LEDs are paralleled, each with its own limiting resistor, per transistor.

The 120R resistor limits the current to about 20mA per string and therefore two strings per BC548 can be used without exceeding its ratings.

Rhythm Machine

You can have lots of fun with this simple rhythm machine. The MM5871 is a Motorola rhythm generator chip with selectable rhythms and instruments. The tempo is varied by a 1M pot. The selected MM5871 output is amplified by a small power amp IC to drive a speaker. Note that +5 V and +12 V supplies are needed.



Random tone generator

When David Hughes of Howrah Tasmania was working on a project to design a reasonably small robot he found that he needed a randomly sequenced 10-note generator to provide his 'pet' with a voice.

The MM5837 is a bit unnecessary (a fast clock would do) but I found that the random sequences would be better if this chip was used. The MM5837 supplies noise to the 4066 digital switch and the clock formed by the two 4011 NAND gates periodically lets a few noise spikes through via the switch control pin 13. The clock operates at about 1-2 Hz with the $4\mu\text{F}$ capacitor.

The noise spikes are fed to the clock input of a 4017 decade counter/decoder. When a logic '1' appears at pin 13 of the 4066 the 4017 is clocked a random number of times.

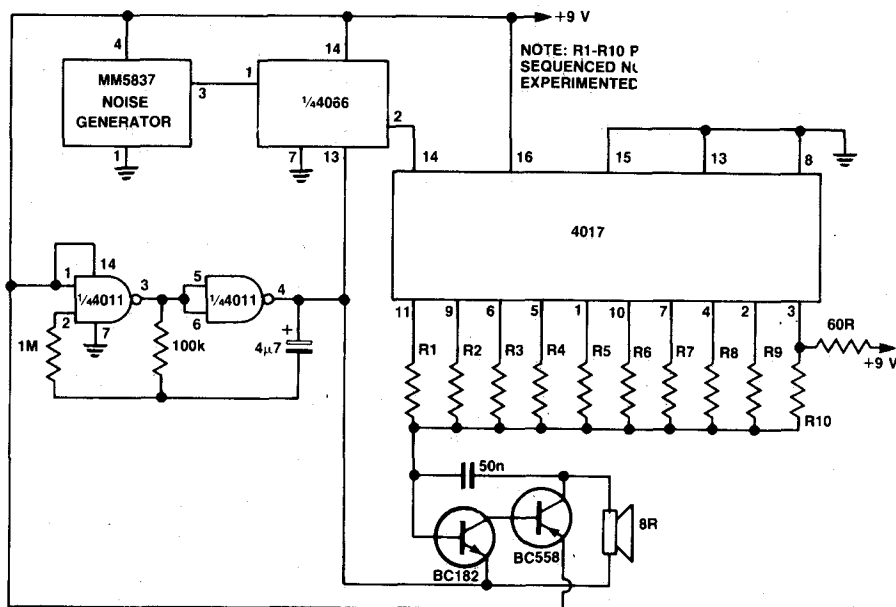
When the 4011 clock output is high the 'organ' formed by the transistors and resistor network

is off so that notes cannot be produced while the 4017 is being clocked. This stops a terrible racket from being produced each time clocking occurs. When the 4011 clock goes low

again, the tone generator is switched on and the tone selected by the 4017 is played.

As each pulse received by the counter moves the logic '1' output to a different pin i.e. pins 1,

2, 3, 4, 5, 6, 7, 9, 10 or 11 when clocking has finished, the logic '1' could be on any of these ten outputs because of the random noise spikes that produced the clocking.

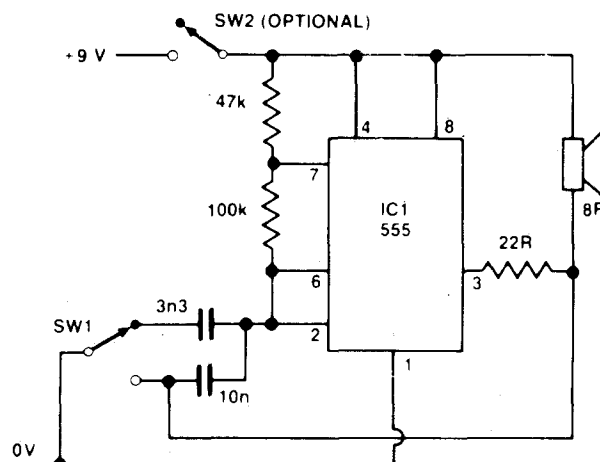


Mosquito imitator

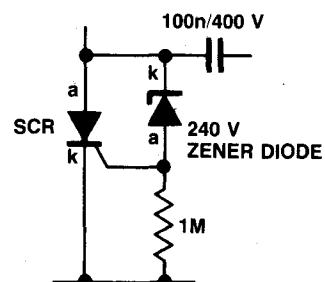
Matthew Sorrell of Clarence Park SA is 10 years old and designed this circuit which produces a sound like a mosquito buzzing.

For Christmas 1978 I was given the ETI-062 AM tuner with which I had a great deal of enjoyment. Since then I have built other projects from Project Electronics on a SK-10 board, including the Morse Practice Set.

My dad brings home ETI and I have a lot of fun trying out the circuits.



Strobe modification



PORTION OF SCHEMATIC DIAGRAM OF STROBE SHOWING MODIFICATION

Mark Hedley of Chatswood NSW constructed the disco light strobe project ETI-574, and found a few problems with it.

He found that the flash rate was slightly irregular and dependant on the ambient light level.

The problem was solved by replacing the neon indicator tube with seven 33 V zener diodes, to give a total zener voltage of 231 V.

$$F_{\text{AUDIO}} = \frac{1}{1.4 R_1 C_1}$$

$$= 190 \text{ Hz}$$

$$F_{\text{SWITCH}} = \frac{1}{1.4 R_2 C_2}$$

$$= 1.9 \text{ Hz}$$

Two-tone siren

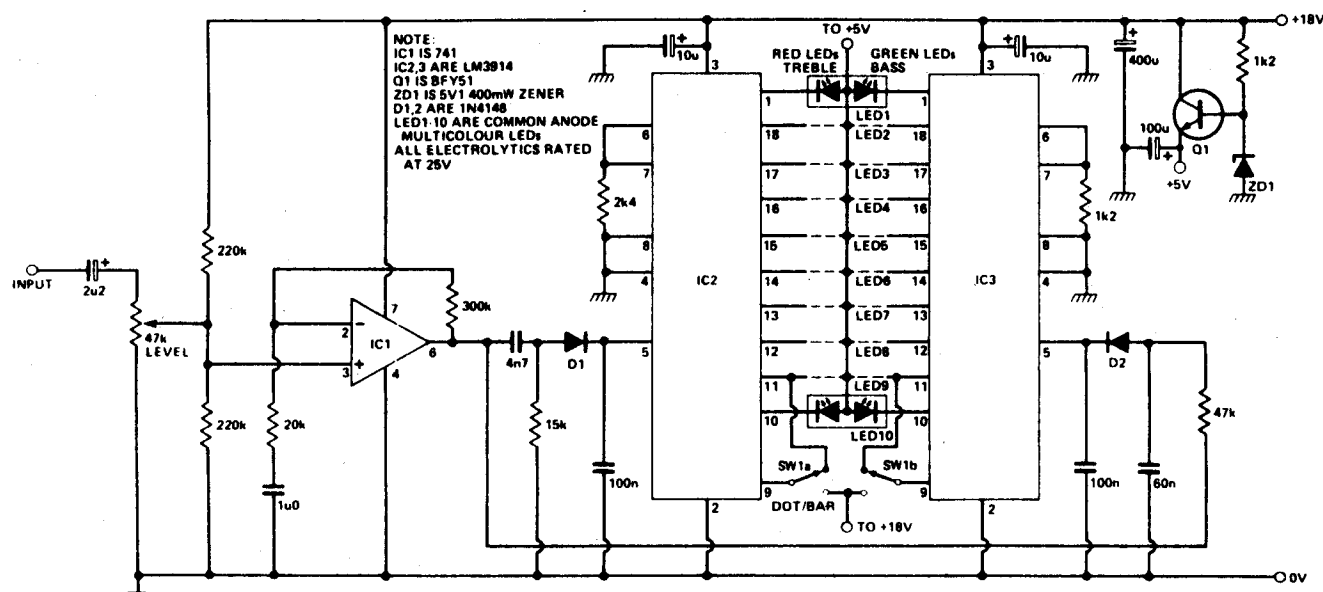
BASIC TONE = 190 Hz
SWITCHED TONE = 260 Hz

$$F_{\text{SWITCH}} = \frac{1}{1.4 R_1 C_1}$$

$$= 1.9 \text{ Hz}$$

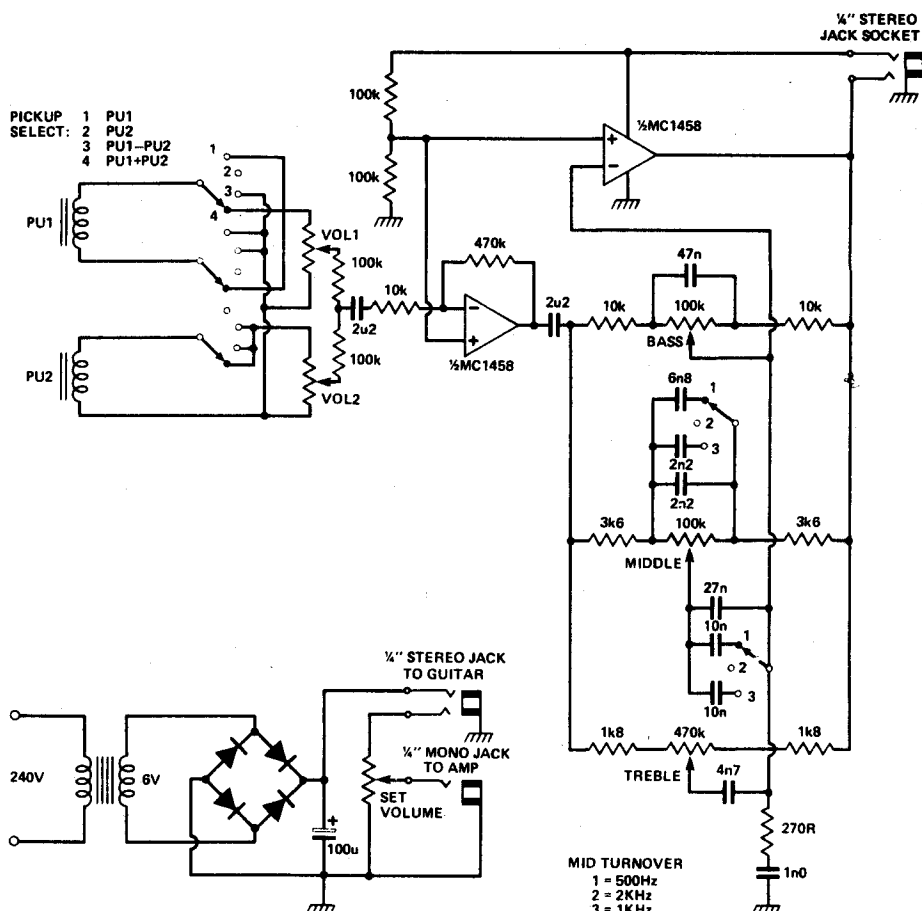
Simple visual sound analyser

weird. The circuit is fairly self explanatory. Be sure to wire the 10uF electrolytics close to the chip, and use a well regulated supply at 12V (maximum), 250 mA (minimum).



Electronic guitar

The circuit shown here was fitted inside a friend's Rickenbacker bass to increase the versatility of the guitar. Its controls are as follows: pickup/phase select, volume 1 and 2, bass, middle and treble tone controls and middle turnover frequency. It has low current consumption and can be used either with a battery, or with the 'phantom' power supply connected to the jack socket. It seems likely that most guitars will feature active circuitry in the future, giving musicians greater flexibility during a live performance.



Sub-octave analyser for ETI synthesiser

Ken Stone, of Cheltenham in Victoria, devised this sub-octave oscillator for his ETI synthesiser and passes it on for other ETI synth owners.

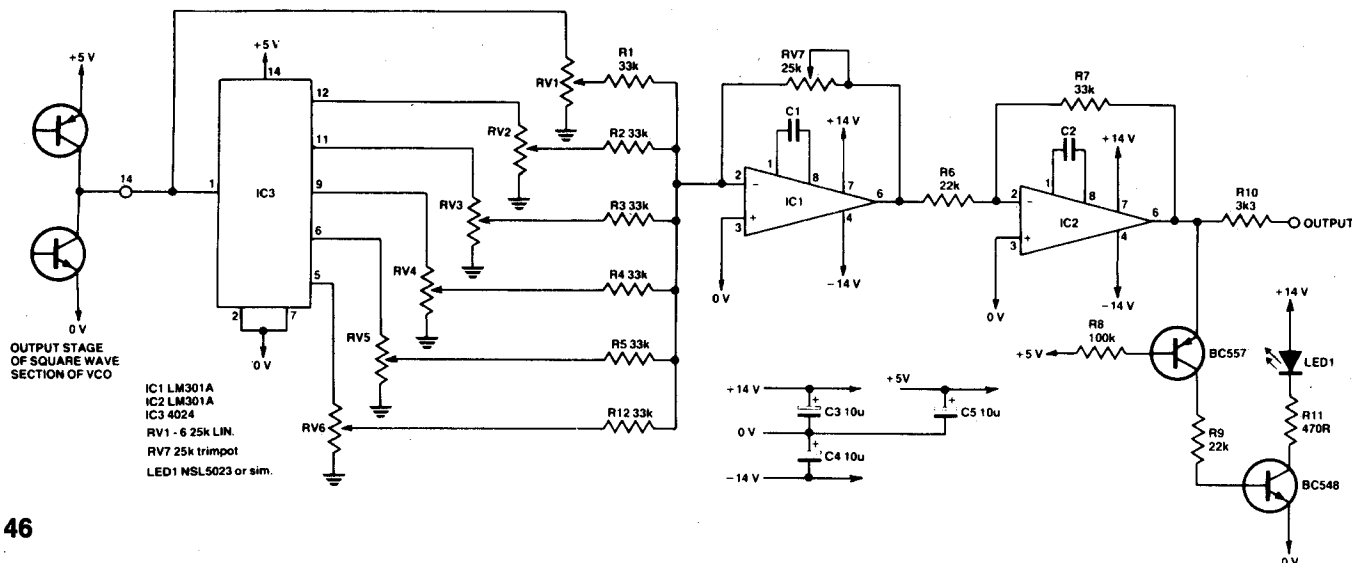
Each sub-octave is created in the 4024 (IC3) by the division of the original frequency. Five sub-octaves are created and mixed together, along with the orig-

inal square wave, in a mixer which is based on the synthesiser's mixer (board 601b). No level control is put on the front panel; level can be adjusted by RV7. This is because the unit is installed between one VCO's square wave out position on the waveform selection switch of the VCO, allowing the volume

to be controlled by the existing mixer.

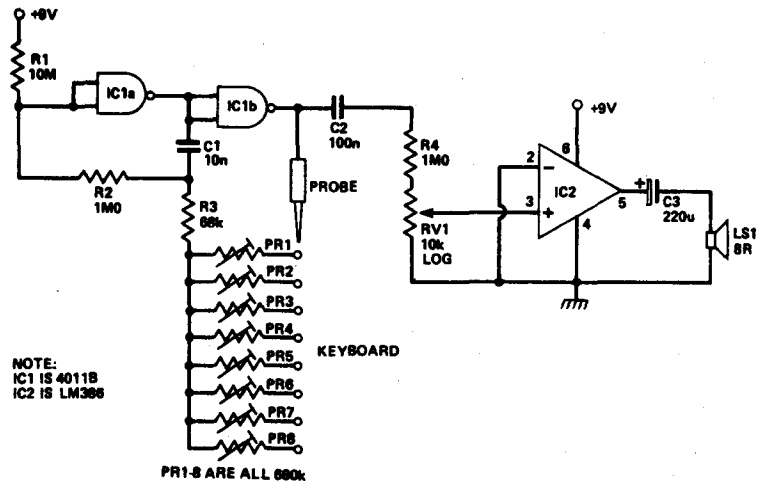
When using the unit, switch the VCO 'range' control to one of the higher frequencies.

The sub-octave unit could be mounted in a utility box bolted to the top of the synthesiser. It can be used to create 'warm' and deep 'feelable' sounds.



Simple organ

With the financial climate being what it is, the following circuit may be of interest to harassed parents whose children want a stylophone. A simple oscillator is formed with two CMOS NAND gates (half a 4011B). Under quiescent conditions no sound is emitted. When the stylus is placed on the keyboard, the circuit is made through the selected preset and the oscillator produces a square wave which is coupled to the output stage, an LM386. This IC is ideally suited to this application since its maximum output is limited to 200 mW and its quiescent current consumption is 3 mA. This, together with the fact that both ICs will work with battery voltages as low as 4 V, means that a fairly long battery life can be expected.

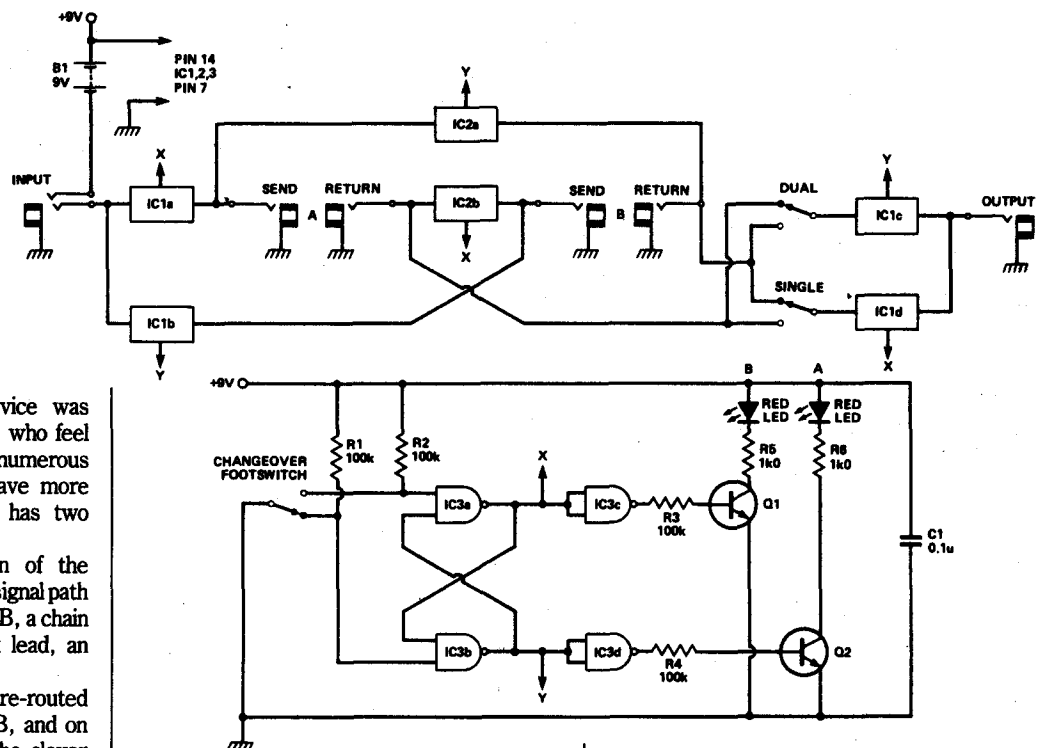


The organ will obviously require some form of keyboard. A simple one can be made from a piece of 0.15" matrix Veroboard with alternate tracks removed.

Tuning is most easily done with the aid of a digital frequency meter; if all else fails, the instrument can be tuned by ear against a piano.

De-luxe AB box

NOTE:
IC1 IS 4016
IC2 IS 4016
IC3 IS 4011
Q1,2 ARE ANY MEDIUM GAIN
SMALL SIGNAL NPN TRANSISTOR
e.g. BC108 etc.



This audio line signal routing device was designed for one of those guitarists who feel insecure unless surrounded by numerous effects boxes, but who wish to have more control over them collectively. It has two modes: single and dual.

In the single mode, depression of the footswitch noiselessly re-routes the signal path from going through chain A, to chain B, a chain being either a straight jack to jack lead, an effect, or a series of effects.

In the dual mode, the signal is re-routed through chain A followed by chain B, and on depressing the footswitch (here's the clever bit) the signal is re-routed to chain B followed by chain A.

The two LEDs indicate the chain selected in the single mode, and in the dual mode — the first chain.

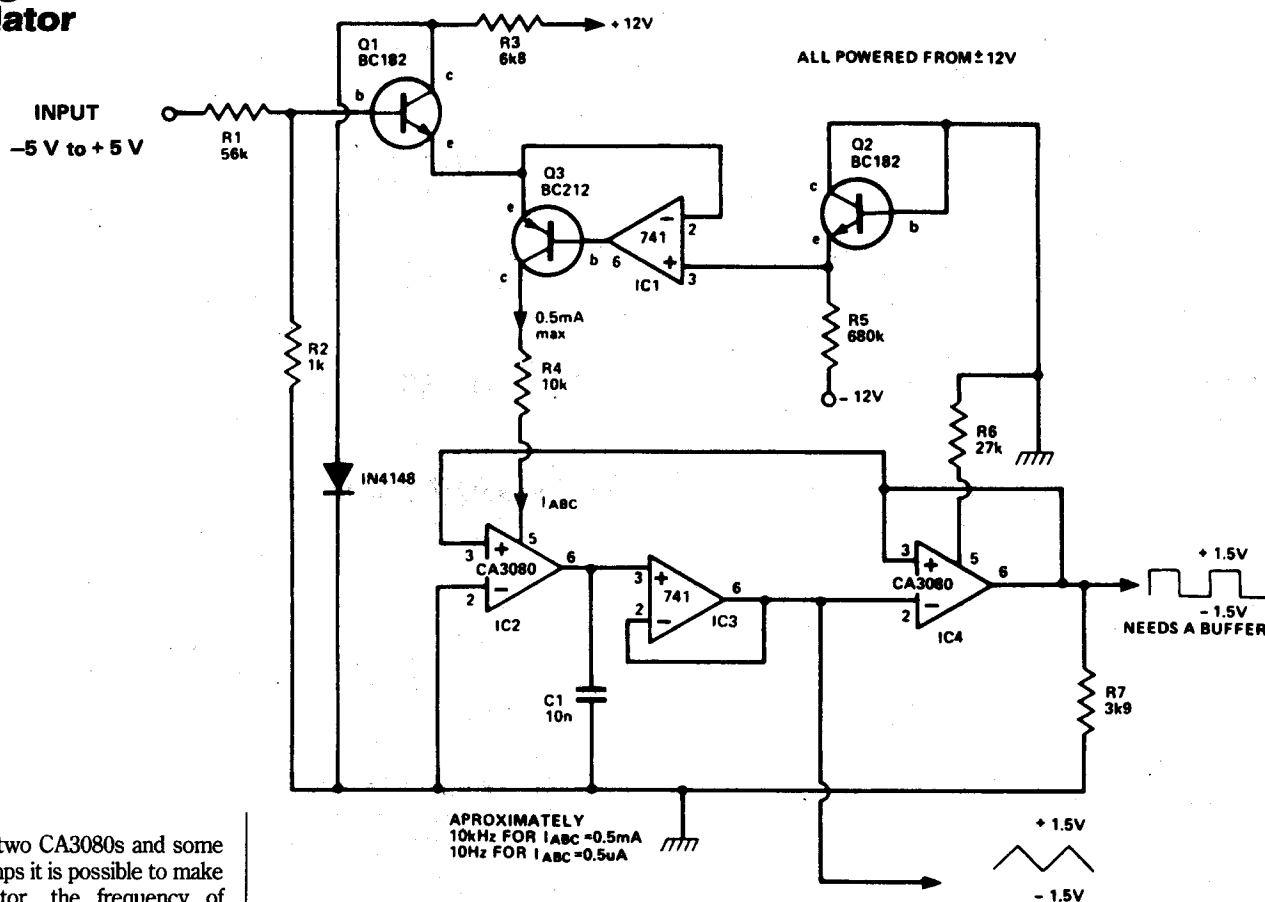
The flip-flop ensures the bilateral switches used change state cleanly and quickly and, more importantly, at the same time.

Current consumption, which is mainly determined by the LEDs, is low enough to allow a PP3 to be used as power. The LEDs were considered essential for ease of use.

The device can be conveniently constructed in an aluminium box measuring about 100 by 100 by 40 mm, with the input socket arranged so that the input plug connects the negative supply.

By using various combinations of sockets, the device can be utilised in many more audio signal re-routing applications, eg, by using the A and B return sockets and output only, (with a dummy plug inserted into the input socket to provide power) the box can be used as a single selector.

Voltage controlled oscillator



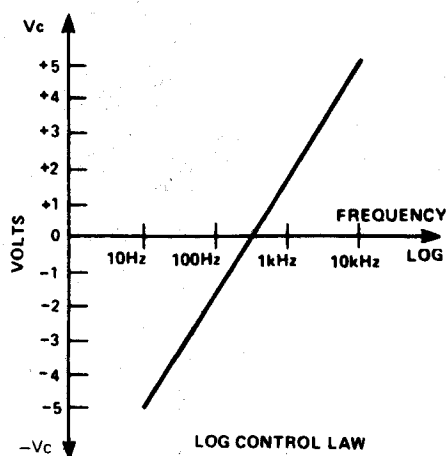
By using two CA3080s and some 741 op-amps it is possible to make an oscillator, the frequency of which is voltage controllable. The circuit has logarithmic control, that is frequency doubles for every volt increase in the control voltage.

This makes it ideal for musical applications where linear control voltages need to be converted into musical intervals (which are logarithmically spaced) and also for audio testing where frequencies are generally measured as logarithmic functions.

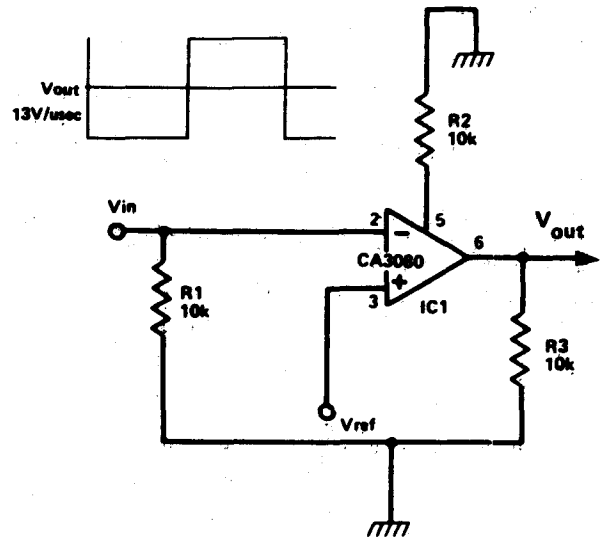
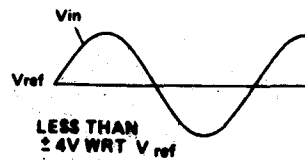
In the example shown, the VCO produces both square and triangular outputs. Using the component values shown, varying the input voltage between -5 volts and +5 volts, causes a corresponding change in output from 10 Hz to 10 kHz — a range of 1000:1. Reducing C1 to 1 n will increase the maximum frequency to 100 kHz, but the waveform quality maybe somewhat degraded.

Changing C1 to 1 μF (non-polarised) will result in a minimum frequency of 0.1 Hz.

The accompanying graph shows the voltage versus frequency characteristics of the circuit.



Tone-burst generator



Example of a fast comparator.

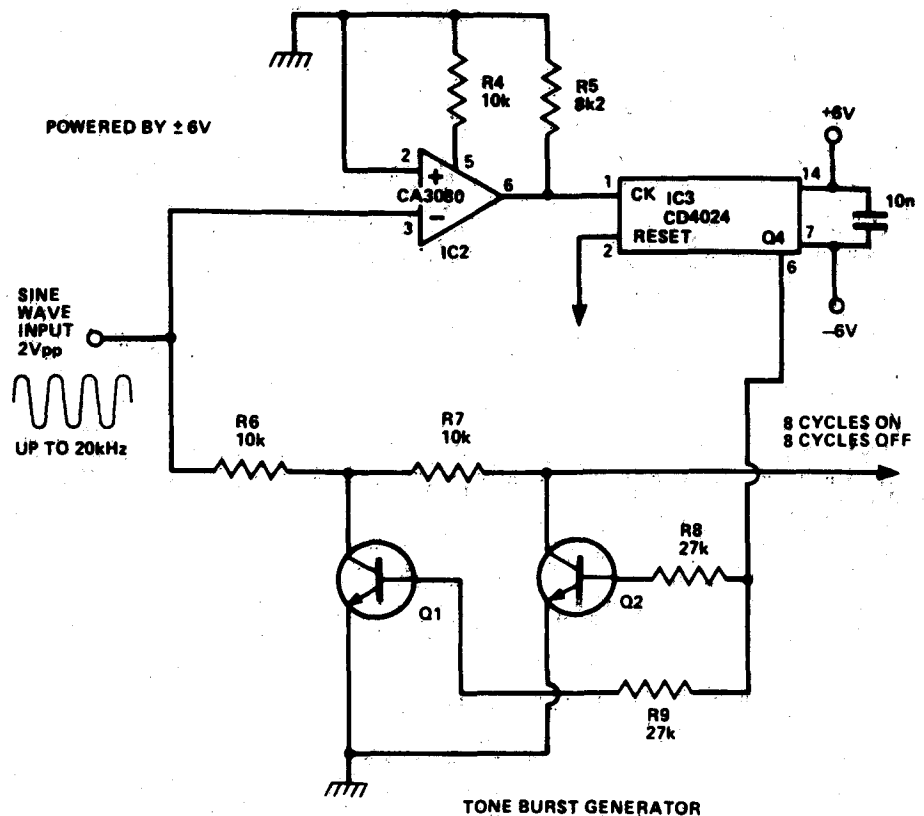
The high slew rate of the CA3080 make it an excellent fast voltage comparator.

In the circuit shown here, when pin 2 of IC1 is more +ve than V_{ref} , the output of IC1 goes -ve and vice versa. V_{ref} can be varied so the point at which the output changes can be varied. If the input sinewave is large (1 V) the output moves very quickly but care must be taken not to overload the inputs.

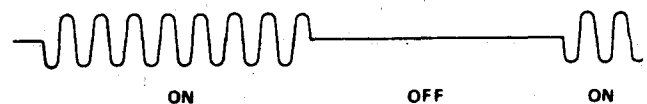
The circuit is suited to use as a tone burst generator. Here the CA3080 is used as a comparator detecting zero volt axis crossings producing a square wave output driving a divide by sixteen binary divider (IC3). The divider's output is high for eight sinewave cycles and low for the next eight, and gates the sinewave on and off.

The gate mechanism is a pair of transistors which ground the sinewave when the divider output is high and let it pass when the output is low. The resulting output is a toneburst.

The circuit shown will operate up to 20 kHz.



A fast comparator is used in this tone burst generator, producing eight cycles of tone with eight cycle breaks starting and finishing at on-axis crossings.

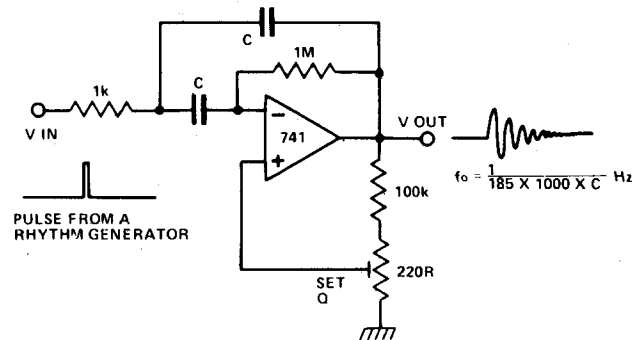


Charming chime

This circuit enables you to add a 'chime' output to a percussion synthesiser. It is multiple feedback bandpass filter that 'rings' in response to a narrow pulse input. The 220R preset labelled 'set Q' provides variation of the positive feedback. It should be set for best 'ringing' results.

A short pulse applied to the input causes the circuit to break into damped oscillation — the amplitude of the oscillation peaking rapidly and then dying away exponentially — hence the ringing or chime sound, as if you struck a bell. The higher the Q, the longer the decay time.

If the oscillation frequency, f_o , is set in the upper audio range, you get a 'tinkling' sound, whereas lower frequencies sound like claves or bongos. By arranging several circuits with their inputs in parallel and their outputs mixed together, all with different tunings, an interesting chime chord can be produced. For better performance, an op-amp with wider bandwidth than the 741 should be used. e.g.: TL071, 5534 etc.



Guitar wah-wah unit

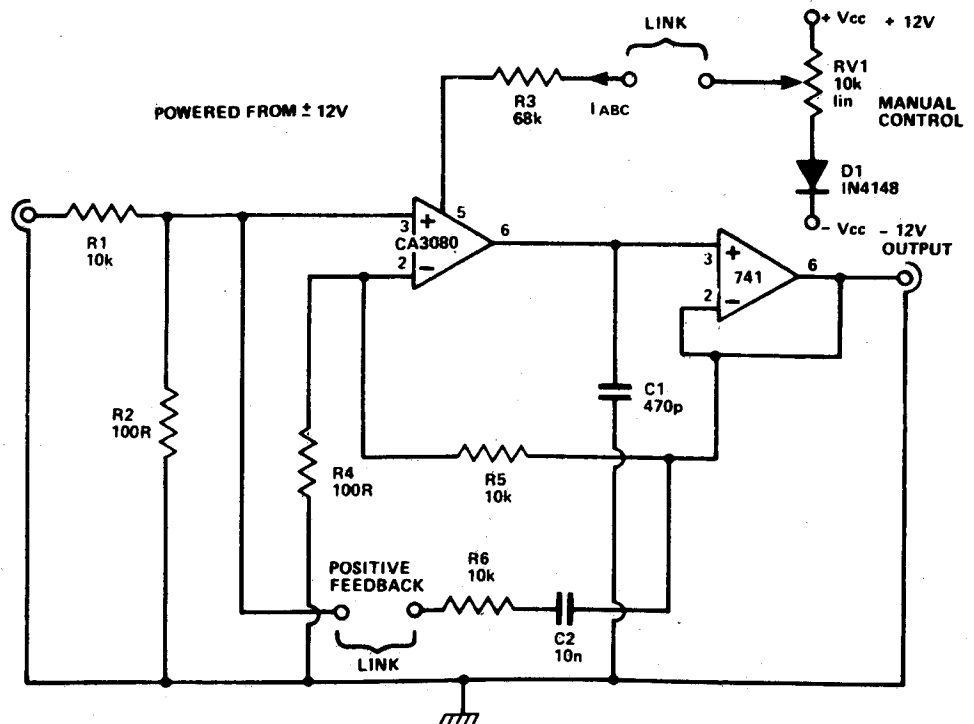
This guitar wah wah circuit uses a filter which can be manually swept across the middle of the audio frequency range.

A single pole, voltage-controlled, low-pass filter can be constructed using a CA3080 as a current-controlled resistor.

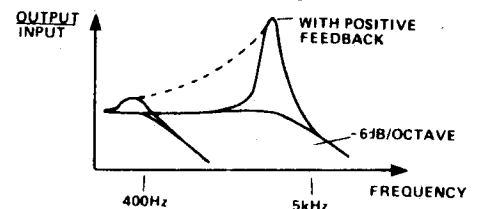
A simple low-pass RC filter configuration is used, the controllable 'R' is the CA3080 and the 'C' is C1. This circuit configuration would normally be a slew limiter, except that the signal level is kept deliberately low (R1 and R2 form a 100:1 attenuator) so that the IC operates in a linear mode. This enables it to look like a variable resistor, which when varied, varies also the break frequency of the filter.

By applying positive feedback around the filter (R6, C2) it is possible to produce a peaky filter response. The peak increases with frequency, producing the wah wah effect.

As shown, the circuit can be swept from about 400 Hz to about 4 kHz.



A guitar wah-wah unit can be made with a swept frequency single pole filter.



How the single pole filter affects the frequency response of the signal passed through the wah wah unit.

Swept frequency VCD filter

A dual integrator filter can be produced using a few CA3080s.

By varying IINFABC, the resonant frequency can be swept over a 1000:1 range. IC1 and IC3 are two current-controlled integrators. IC2 and IC4 are voltage followers which serve to buffer the high impedance outputs of the integrators. A third CA3080 (IC5) is used to control the Q factor of the filter. Q factors as high as 50 can be obtained.

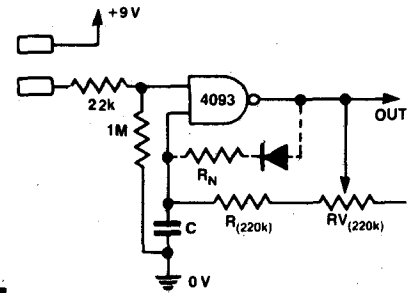
The resonant frequency of the filter is linearly proportional to IINFABC hence this unit is very useful in electronic music production.

There are two outputs, a low pass and a band pass response. Minimum frequency is around 7 Hz to 10 Hz, upper frequency is around 7 kHz to 10 kHz or so. Changing C2 and C3 will alter the upper and lower frequency limits.

Rich harmonics for ETI-905

The original circuit for the ETI-905 polyphonic organ produces predominately odd harmonics which P.M. Connor of Kuranda Qld found a bit boring.

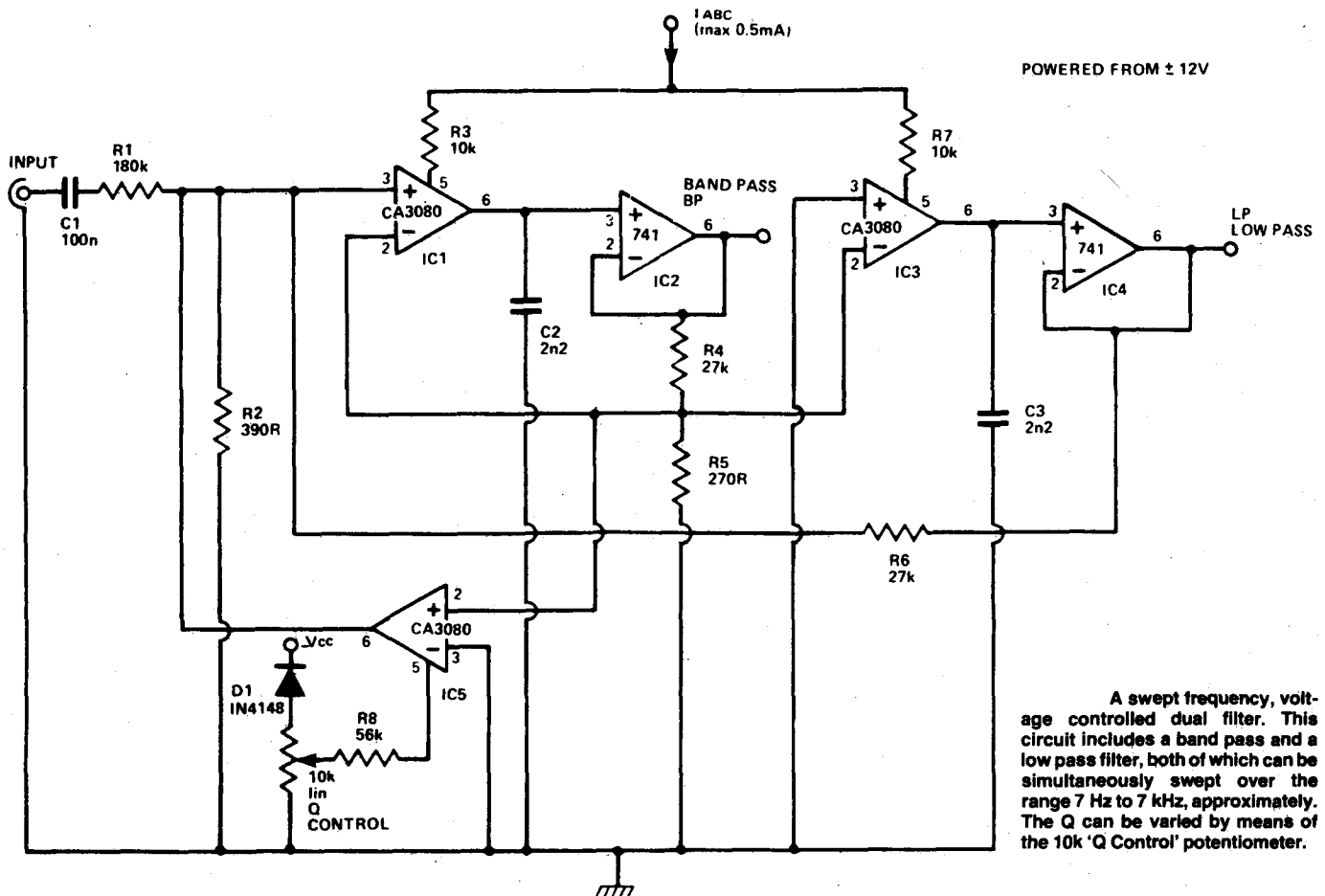
An extra resistor and diode on each oscillator are all that is required to make the mark/space ratio uneven, producing a rich range of even as well as odd harmonics.



The exact mark/space ratio chosen is a matter of taste, but about five to one is reasonable.

The new circuit is shown with the added components dotted in.

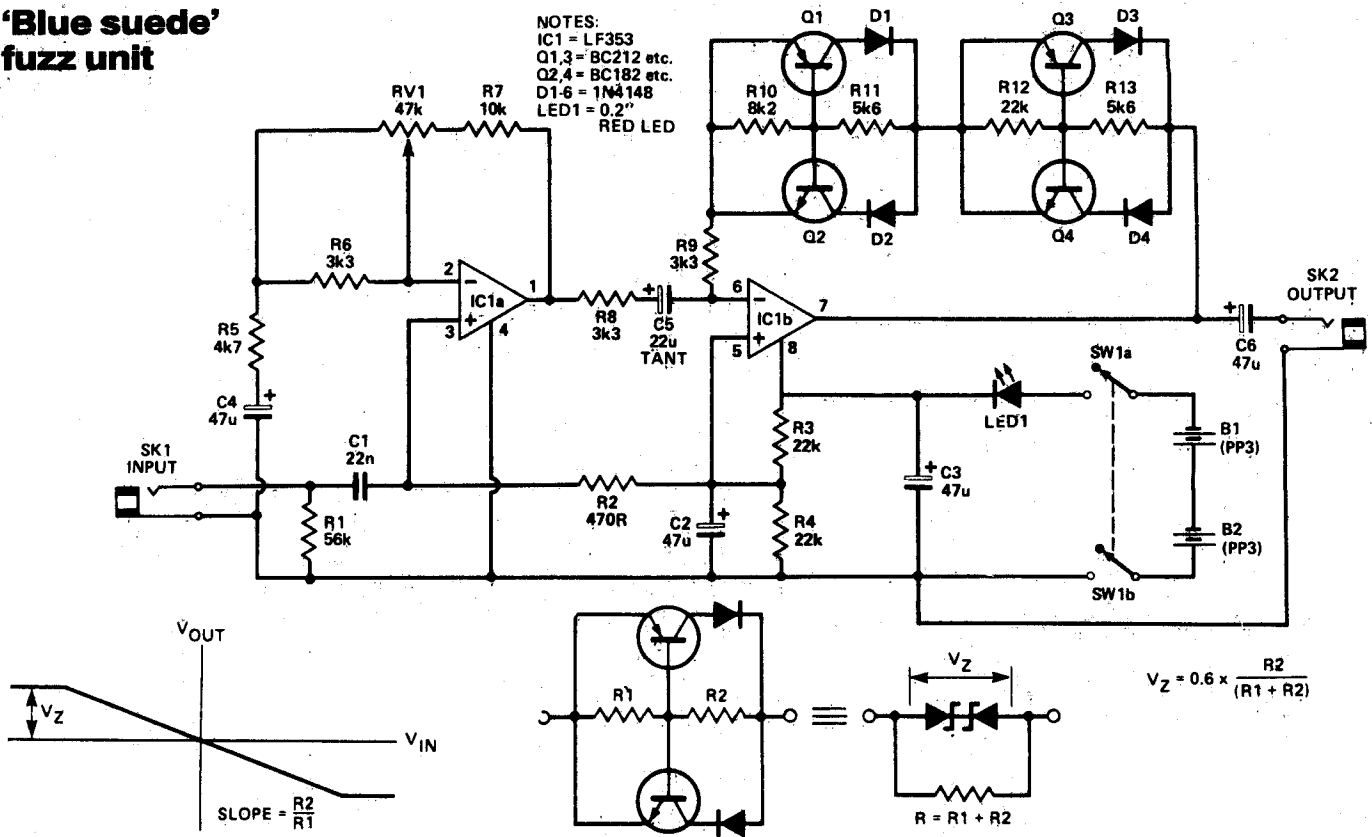
If the new mark/space ratio is to be 5:1, R_N should be about 47k and the value of C should be approximately doubled to achieve the same note.



A swept frequency, voltage controlled dual filter. This circuit includes a band pass and a low pass filter, both of which can be simultaneously swept over the range 7 Hz to 7 kHz, approximately. The Q can be varied by means of the 10k 'Q Control' potentiometer.

'Blue suede' fuzz unit

NOTES:
IC1 = LF353
Q1,3 = BC212 etc.
Q2,4 = BC182 etc.
D1-6 = 1N4148
LED1 = 0.2"
RED LED

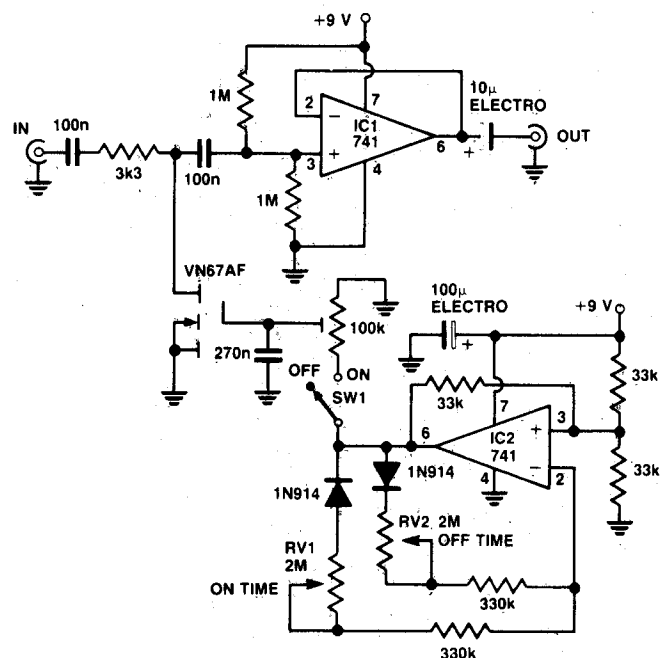


This guitar effects unit provides 'soft fuzz', giving a reasonable approximation to valve guitar amp sound. A series of 'active zeners' are used in the feedback of the op-amp IC1b. A third active zener can be added to give an extra breakpoint. The existing breakpoint can be adjusted by varying the values of resistors 10, 11, 12 and 13.

Chopper echo effects

Music signals which have a sharp attack/slow decay envelope, such as guitar etc, can be 'chopped' to give an effect not unlike an echo. Here, IC1 is just a unity-gain non-inverting amplifier. The VN67AF FET is turned on and off to short the signal or pass the signal, respectively. If this is done at a slow rate to a slowly decaying note, an 'echo' effect is obtained.

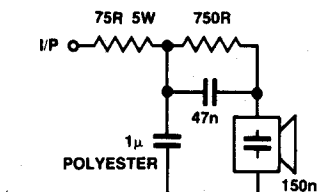
IC2 and associated components form a low frequency pulse generator in which the 'on' and 'off' times can be independently set by RV1 (on time) and RV2 (off time). The 100 k preset determines the amount of attenuation afforded by the VN67AF (effect 'depth').



Motorola speaker filter

Phillip Denniss of Chippendale NSW has designed a circuit to smooth the lower cut-off point of Motorola Piezo Ceramic speakers, in particular, the 3½" Super Horn (models KSN 1001A, 1005A, 1032A and 1003A).

Although they are rugged, very efficient and reasonably cheap, they suffer from a fairly high, lower cut-off point at about 4 kHz with a very savage cut-off slope of approximately 20 dB/octave. The proposed circuit smooths out the fast cut-off at the expense of sensitivity. However, the loss of sensitivity is not really a problem since the drivers are very efficient.



The circuit is a two stage filter made from resistors and capacitors only. No inductors are used which makes the circuit attractive, and the input impedance is still quite high, preserving the 'no load' effect of the driver.

The idea was to reduce the cut-off slope to about 6 dB/octave for as long as possible without undue loss of sensit-

ivity. Therefore the 3 dB of the filter was chosen at about 2 kHz. This determines where the roll-off resumes its rapid plunge. The second half of the filter has a step response, where roll-off starts at about 1 kHz and levels out again around 4.5 kHz.

The capacitive load presented by the tweeter (150n) is quite handy, and I use it as part of the filter. It also allows the use of filter sections that are basically non interactive, which simplifies design and implementation.

The circuit was originally used with Magnavox 8-30 bass drivers as a stop gap measure.

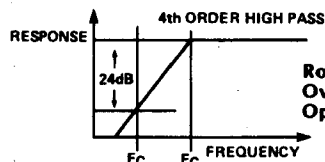
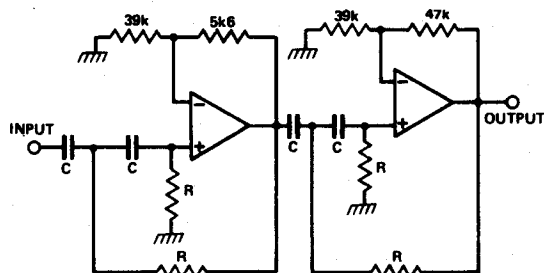
The filter significantly cuts

back the harshness of the tweeter since it broadens the response, although I did find it necessary to use a little treble boost to add some brilliance. I had hoped that the staggered roll-off points would smooth the response without too much attenuation, since the signal to the tweeter is basically reduced by the same factor as the roll-off point.

By including a resistor of 20-30 ohms in series with the 1µ capacitor, the first section of the filter can be altered to give a step response similar to the second section.

Well it's worth trying and the only really expensive part is the tweeter.

Rumble filter

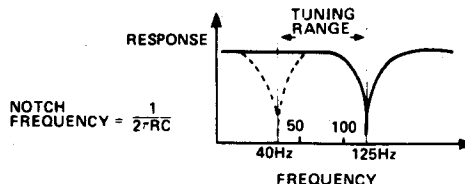
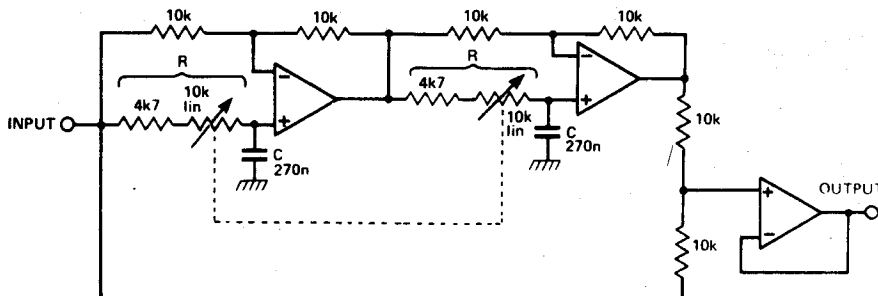


F_c	C	R
25 Hz	100n	62k
50 Hz	100n	30k
100 Hz	100n	15k
200 Hz	100n	7k5

(5% tolerance)

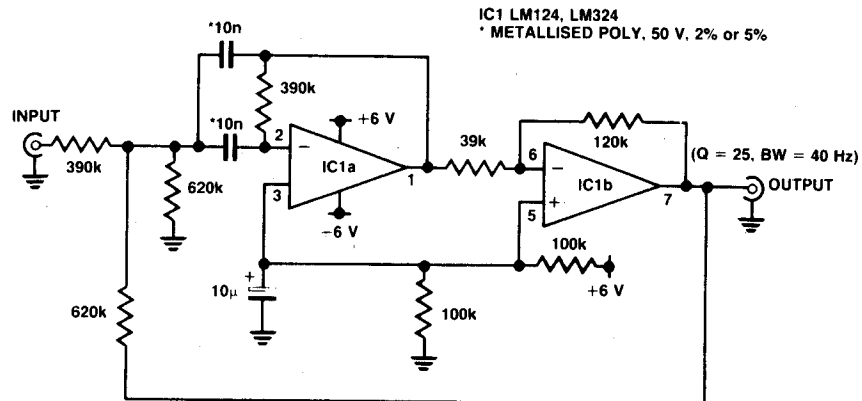
Notch filter

An audio notch filter has many and varied applications. This circuit will provide a very 'deep' (high attenuation) notch in the input-to-output response at a frequency set by the value of the ganged-pot sections. With the circuit values shown, it is tuneable over a range from about 40 Hz to 125 Hz. Varying the value of C will shift the range up or down the audio spectrum. If you use internally compensated op-amps then no extra frequency compensation will be required. Types such as the NE5534 (N or AN) or TL071 are suitable, or multi-op-amp packs such as the LM324 or TL074 may be employed. Note that C should be a good-quality film or polycarbonate capacitor.



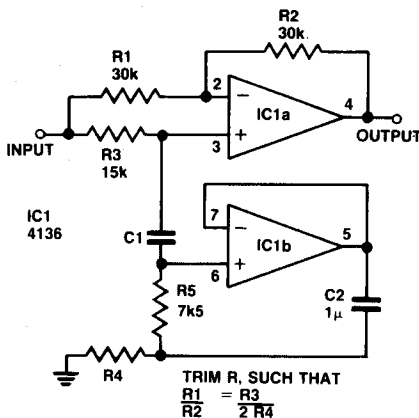
Active 1 kHz bandpass filter

This circuit provides a 40 Hz-wide 'window' at 1 kHz. Two op-amps from a quad op-amp IC are used. For best results, the two 10n capacitors should be metallised poly, low voltage types, with a 2% or 5% tolerance — matched values if possible.

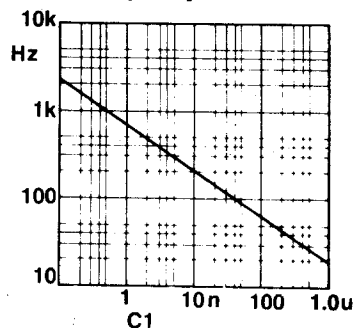


Gyrator audio notch filter

Using two op-amps from a 4136 quad package, you can implement a very effective notch filter with common component values, the notch frequency ranging from 20 Hz to 2 kHz. Capacitors should be good quality, low voltage metallised poly types.



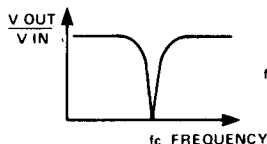
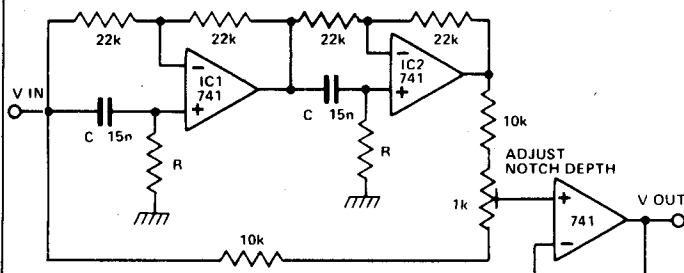
Notch Frequency as a Function of C1



All-pass notch filter

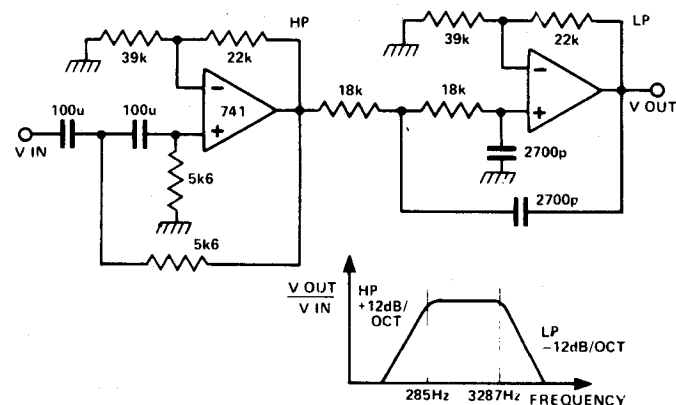
This circuit provides adjustable notch attenuation ('depth'). IC1 and IC2 are arranged as 'all pass' filters. They have a flat frequency response but the phase changes with frequency. Overall maximum phase shift is 360°, a phase shift of 180° (reversal) occurring at a frequency of $1/2CR$ Hz. By mixing the phase-shifted signal with the original, cancellation will form a narrow 'notch' in the frequency response.

The 1k preset varies the amount of phase-shifted signal mixed with the original so the notch attenuation can be varied. The notch frequency, f_c , can be varied by varying the two resistor marked R. e.g. for a notch at 50 Hz, R should be 220k.



$$f_c = \frac{1}{2 \cdot C \cdot R}$$

$f_c = 1\text{kHz}$
 $C = 15\text{n}$
 $R = 10\text{k}66$

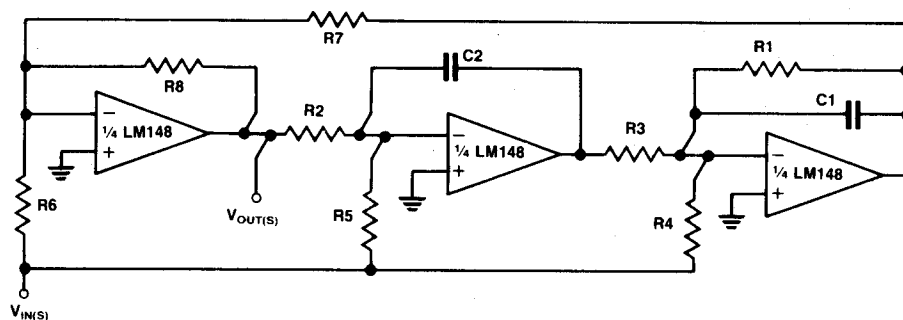


Speech filter

For any purely speech audio system application — communications receivers, transceivers, dictaphones etc. — it is desirable, for best intelligibility, to limit the audio bandwidth to provide relatively steep rolloff below about 300 Hz and above about 3 kHz or so. Most speech information is contained between these limits. This circuit shows a simple bandpass filter system with 12 dB/octave rolloff below 285 Hz and above 3287 Hz. One unusual application of such a filter would be in a 'light show' system so that the display varies with voice variations of an announcer or performer.

Bi-quad notch filter

This notch filter provides good predictability and better noise performance than the state-space approach. Three op-amps from a quad package are employed. For a notch of 3 kHz, R1 is 270k, R2-R3-R5 are 20k, R4 is 27k, R6-R8 are 10k, R7 is 100k, C1-C2 are 1n (use good quality poly or mica capacitors).

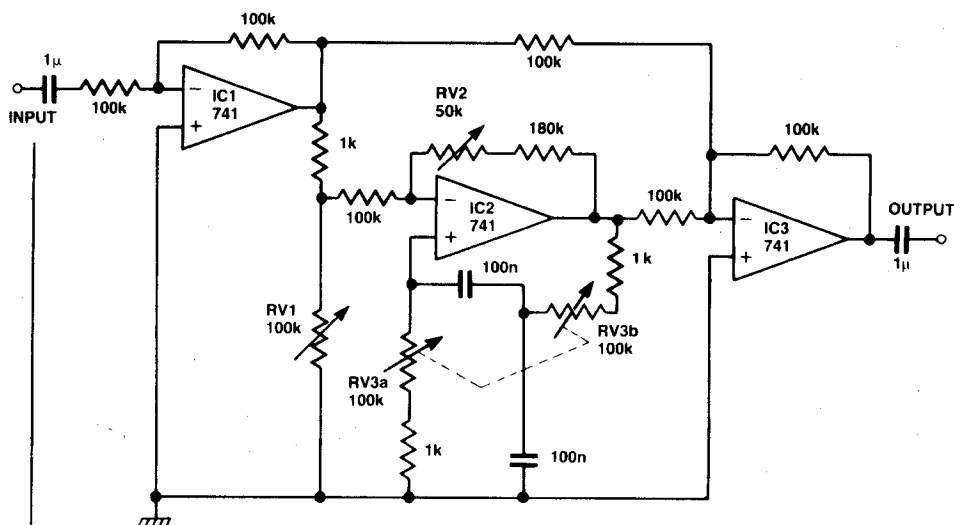


$$Q = \sqrt{\frac{R8}{R7}} \times \frac{R1C1}{\sqrt{R3C2R2C1}}, \quad f_o = \frac{1}{2\pi} \sqrt{\frac{R8}{R7}} \times \frac{1}{\sqrt{R2R3C1C2}}, \quad f_{NOTCH} = \frac{1}{2\pi} \sqrt{\frac{R6}{R3R5R7C1C2}}$$

$$\text{Necessary condition for notch: } \frac{1}{R6} = \frac{R1}{R4R7}$$

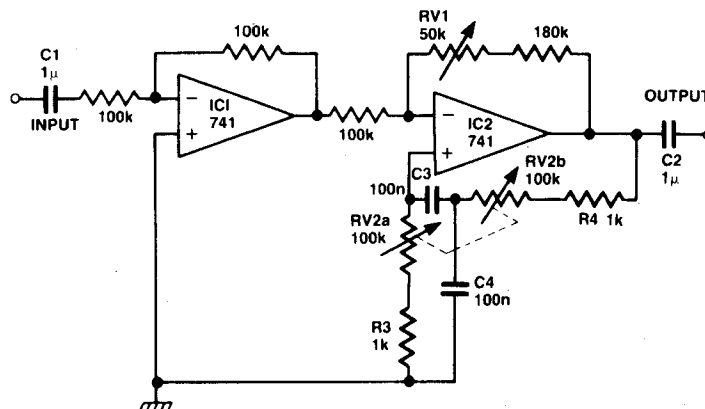
Tunable audio notch filter

This is a modification of the previous circuit to provide a notch, rather than a peak. The original input and the filtered signal are summed in anti-phase at the input of IC3. Hence, the filter circuit provides attenuation at the filter frequency. RV1 sets notch depth, RV2 sets notch width, RV3 sets notch frequency.

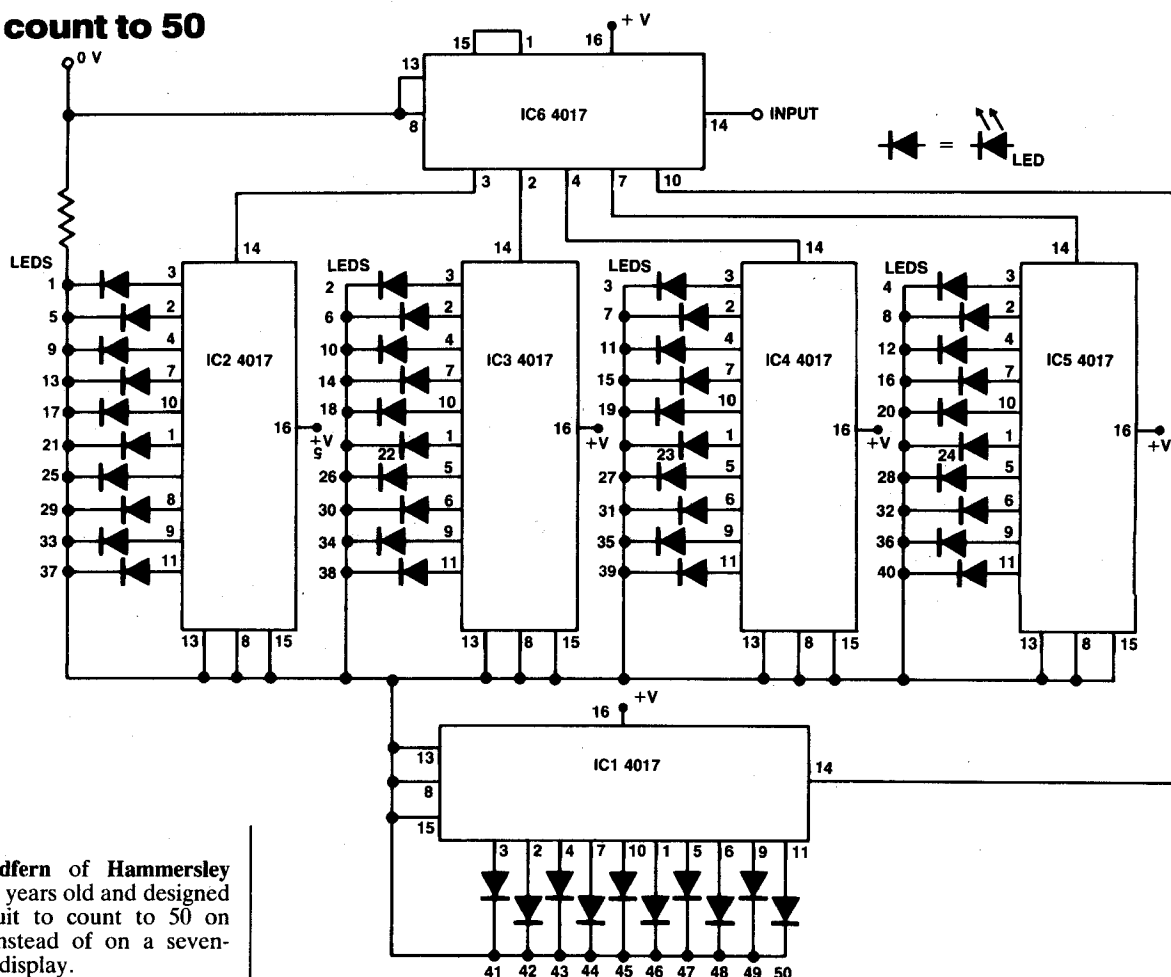


Tunable audio filter with adjustable selectivity

This filter can be tuned from 20 Hz to 1 kHz and has adjustable bandwidth. Potentiometer RV2 sets the frequency, RV1 sets the selectivity. The latter provides positive feedback. Advancing it beyond a certain point causes oscillation. Set it just below the point of oscillation for minimum selectivity. The capacitors should be low voltage metallised polyester components, 5% tolerance or better.



Let's count to 50



Paul Redfern of **Hammersley WA** is 13 years old and designed this circuit to count to 50 on LEDs, instead of on a seven-segment display.

It has a lot of scope for different applications; one way would be to use it to count to 50 for a computer game.

A multivibrator could be added to the input and it could

be used to time someone and you could then time yourself doing the same thing.

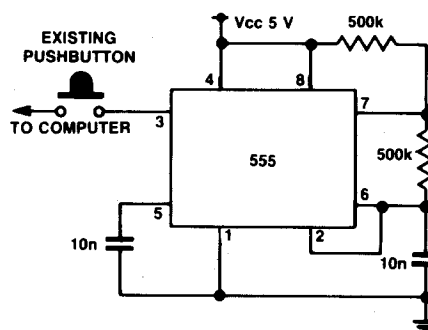
Rapid fire paddle

Here at ETI we suspect this idea is highly unethical, but **Nigel Senior of North Fitzroy Victoria**, has sent us this idea which assures you a better than even chance of winning at Space Invaders.

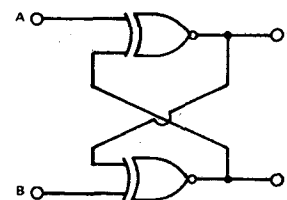
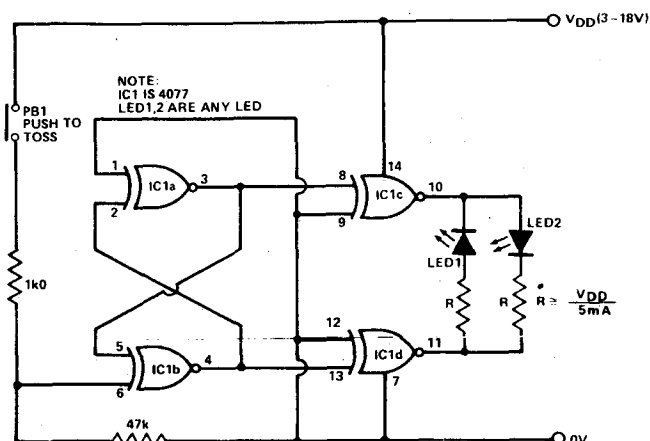
The idea is to put a simple

bistable inside the computer joystick. Pressing the fire button will make the system fire at a rate determined by the software of the game itself.

Now, to give the invaders a chance, play blindfolded!



Heads or tails



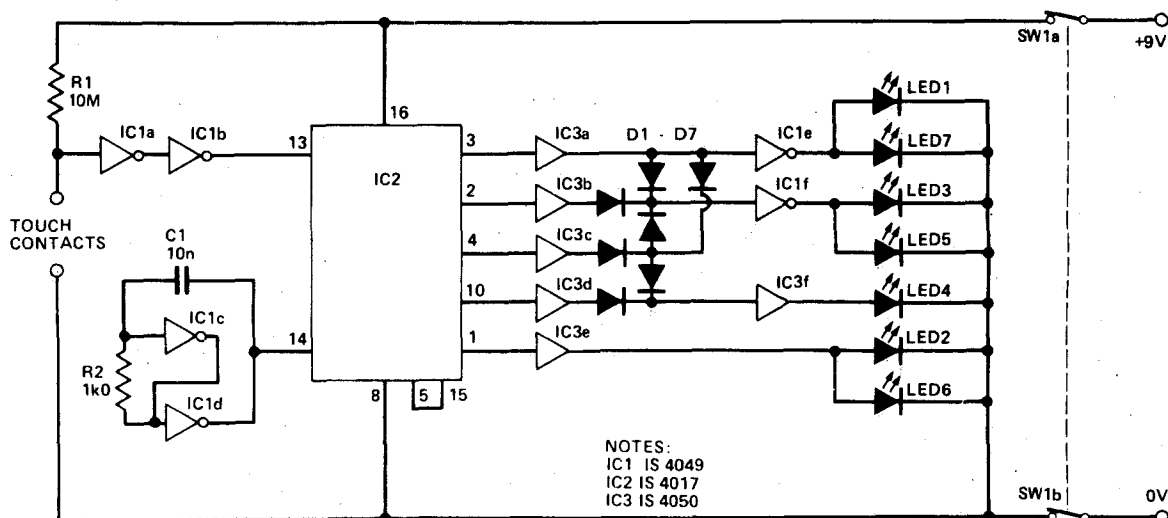
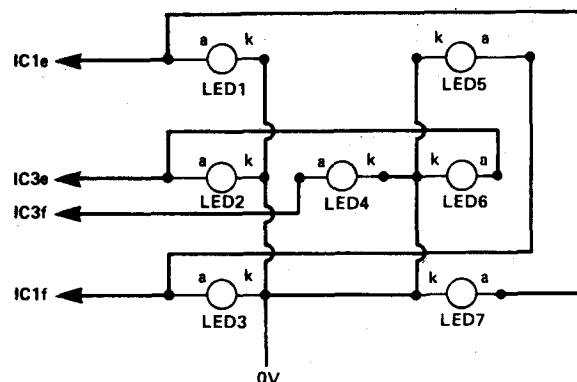
An ultra-simple heads or tails indicator can be built using a single 4077 EXNOR IC. The circuit is normally in a latched bistable mode; when the switch is closed the circuit will oscillate, ie toss the coin. The astable frequency is approximately 5-10 MHz.

If desired a small push-to-make switch can be connected in series with the battery as an on/off switch, such that the battery will be disconnected from the circuit unless the device is being held. The LEDs can be any colour.

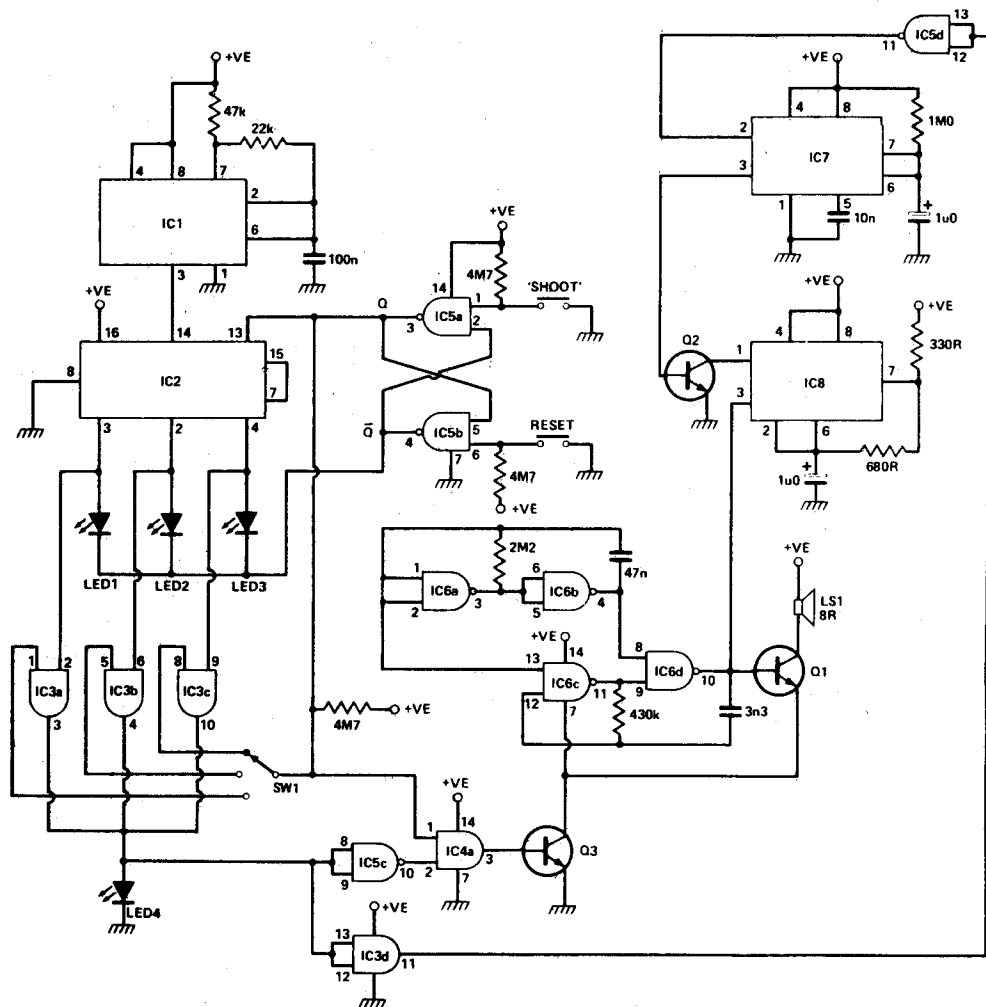
A	B	C	D	MODE
0	0	$\bar{D}$	$\bar{C}$	BISTABLE
0	1	$\bar{D}$	$\bar{C}$	ASTABLE
1	0	$\bar{D}$	$\bar{C}$	ASTABLE
1	1	D	C	BISTABLE

Die/dice roller

A dice is more than one die — it's a six-sided solid with faces numbered 1 to 6. This is the electronic version. It comprises an oscillator and a counter with a 1 to 6 display output to LEDs. The LEDs can be arranged in the traditional die face, as shown.



Penalty kicks



NOTE:
 IC1,7,8 ARE 555
 IC2 IS 4017
 IC3,4 ARE 4081
 IC5,6 ARE 4011
 Q1,3 ARE BC108
 ALL LED'S ARE 0.2"; COLOURS TO CHOICE

We designed this following hand held game to be simple for construction, cheap and most of all fun for the operator. The idea of the game is to put yourself in the position of the goal keeper and to guess which way the striker is going to kick the ball, by turning the rotary switch to the marked positions. The shoot button is then pressed; a noise will indicate whether the operator has guessed right.

IC1, a 555, is wired up as a astable multivibrator running at about 100 Hz feeding the clock input of the 4017. If the 'shoot' button is not operated, the Q output of the latch formed by IC5a,b is low, allowing the

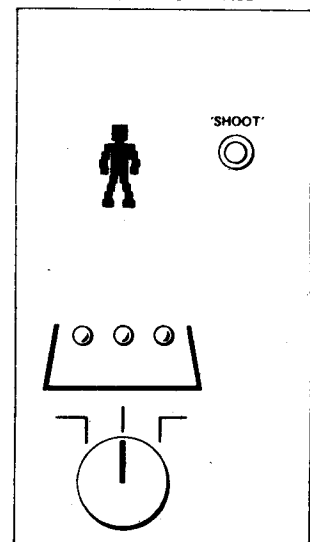
4017 to count. Three LEDs are driven by the 4017; in the reset state these are blanked by the latch.

Switch SW1 is turned into the position the 'goalie' thinks the ball will come towards the goal. The 'shoot' button is pressed. IC2 stops counting and one of the LEDs lights.

If you guessed correctly the 'saved' LED is lit via IC3a,b or c and a 1 kHz sound generator built around IC8 is sounded for just over a second, being controlled by IC7, a one-shot monostable.

If you 'let the ball into the goal' a buzzer is triggered, formed by IC6.

SUGGESTED FRONT PANEL

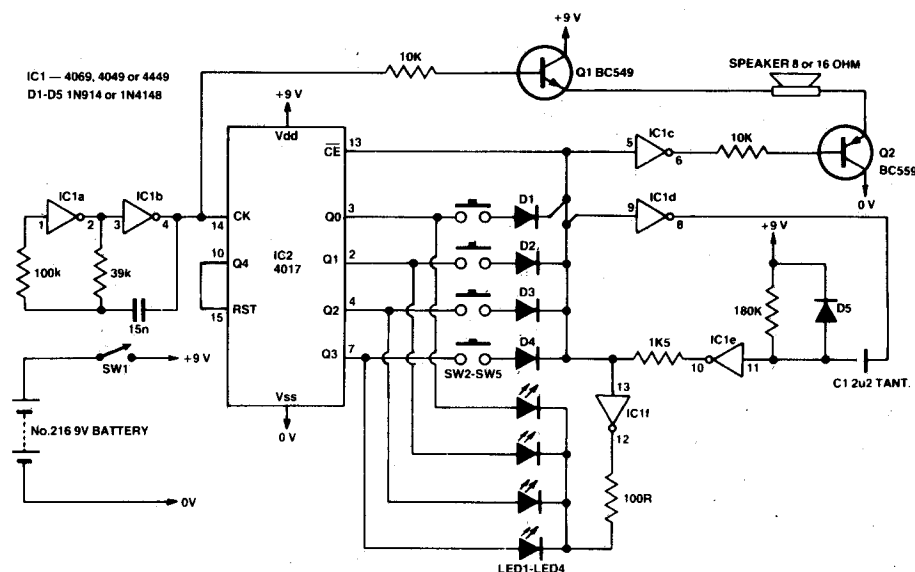


Pick the winner!

This idea, from **J. Gallant of Tasmania**, is useful in competition situations to provide an impartial method of determining which competitor pressed a button first.

The circuit operates as follows. IC1a and b operate as a square wave oscillator with a frequency of about 1 kHz. This clocks the 4017, causing it to scan the switches. If one is closed, the high from the 4017 output will be fed through that switch to the 4017 CE input, which then keeps that output high. At the same time, the appropriate LED is turned on, and the speaker emits a 1 kHz tone.

Now, IC1d and e form a monostable with the input to IC1d normally kept low by IC1e, which has its input pulled high by the 180k resistor on its input. Thus the output of IC1d is normally high, so C1 is discharged. When the input to IC1d is pulled high by the closed switch, its output goes low, pulling down the input to IC1e through C1. C1 now starts to charge up through the 180k resistor. When the voltage across



it reaches the inverter input threshold, the monostable reverts to its original state and C1 discharges through D1. The LEDs and speaker are then turned off; the monostable period is about two seconds.

Current drain is fairly low in the

quiescent state and a 216 type 9 V battery will power this circuit for a fairly long time, as it is normally only used intermittently. None of the components are critical, and the oscillator frequency and monostable period could be changed if desired.

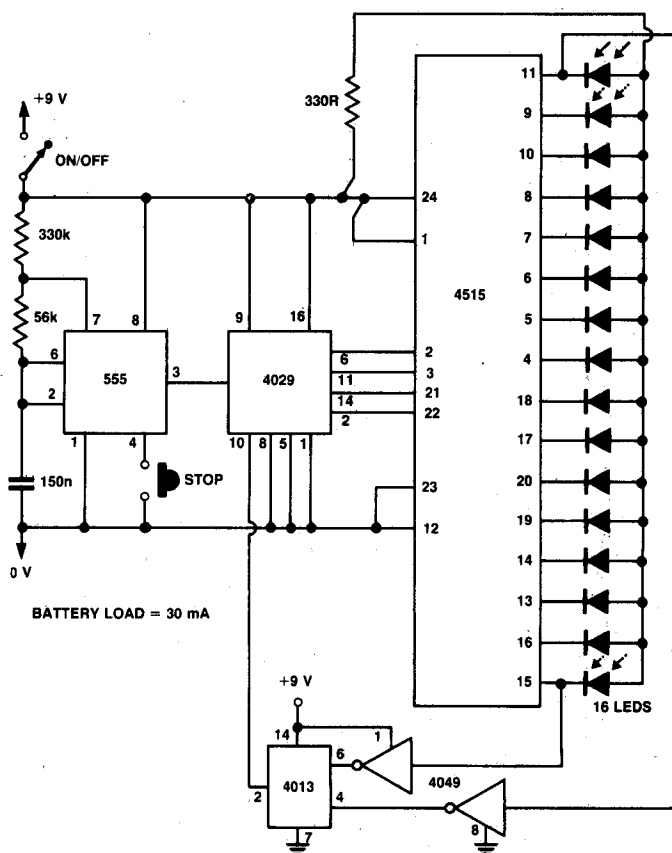
An eye for a Cylon

Recently I went to a fancy dress party and inspired by the TV series, I went as a dastardly Cylon. The voice was provided by your Sound Bender (ETI February 1982). However, I still had to make the single red eye as a blind Cylon at a party is not much chop.

A 555 timer drives a 4029 hex up-down counter. Its output is fed to a 1-of-16 decoder, which in turn lights one of 16 LEDs. The 4013 flipflop is used to change the direction of the counter whenever the first or sixteenth LED lights. The pushbutton is used to stop the eye, as this is what happens when a Cylon 'thinks' hard.

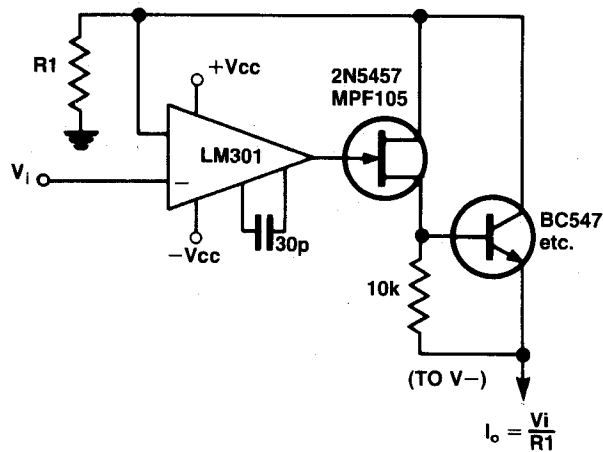
The circuit, mounted in the helmet, looks quite effective and the speed of the eye is about the same as a 'real' Cylon.

Note that the circuit could be simplified by using a 4514 and leaving out the 4029, but I couldn't get my hands on one.



Precision current source

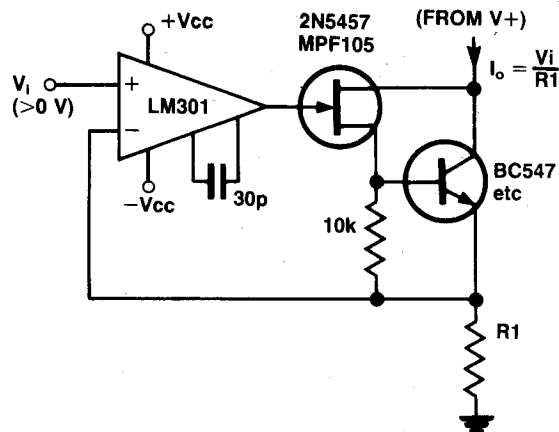
Resistor R1 is the current-sensing resistor here and the FET and transistor serve as voltage-isolating devices between the output and R1. The 301 op-amp provides a large amount of loop gain, assuring the circuit acts as a current source. For current source requirements under 1 mA, the bipolar and 10k resistor can be dispensed with, the output being taken from the FET's source.



Precision current sink

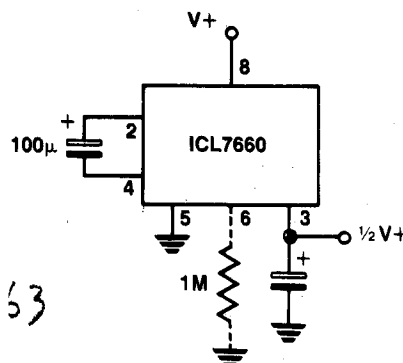
Resistor R1 here is a current-sensing resistor, providing feedback to the 301 op-amp giving a large amount of loop gain for negative feedback to enhance the current sink capabilities of the circuit. The FET and transistor here have inherently high output impedance.

Maximum current capability is limited by the collector current capacity of the bipolar transistor. For low current sink requirements (under 1 mA), the bipolar and 10k resistor can be thrown out and the source of the FET connected to R1.



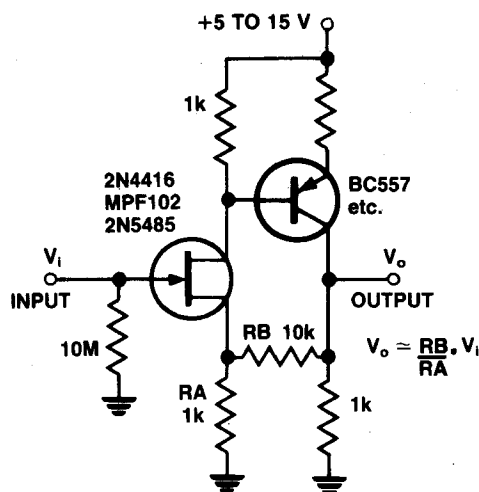
Half-supply generator

The useful ICL7660 positive-to-negative rail inverter can be pressed into service as a half-supply generator where it is desired to use split-supply op-amps from a single supply rail. The ICL7660 can accurately split the supply rail in this application to within $\pm 0.1\%$ for output currents up to 80 mA.



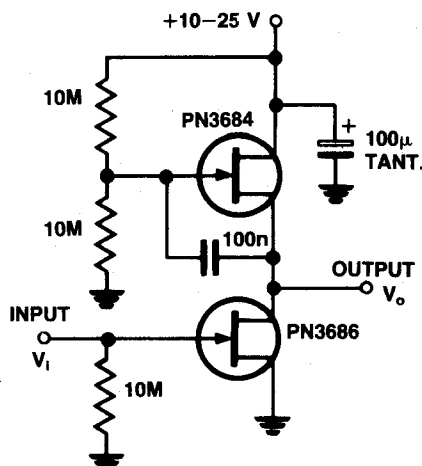
High input Z, low input C amplifier

This circuit makes an ideal wideband video amp. The compound series feedback circuit provides high input impedance with low capacitance and stable gain over a wide frequency range. Good RF construction should be employed, keeping leads short and properly bypassing the supply (a 100n ceramic and a 1u tantalum in parallel are recommended). Note that input and output are in-phase. Varying the value of the 10k feedback resistor will vary the gain.



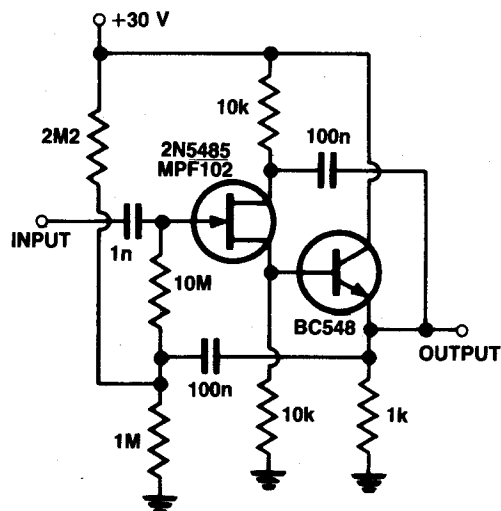
Super high gain amp

This audio amp delivers a gain of 500, taking advantage of the fact that, with JFETs, the μ increases as the drain current decreases — the lower the drain current, the more gain you get. The drawback is, however, that you sacrifice dynamic range with increasing gain.

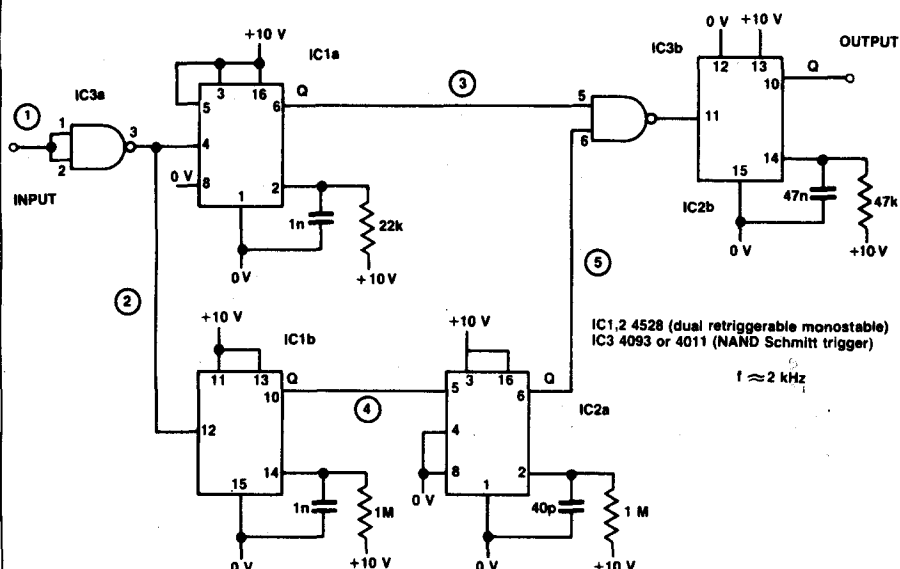


Very high input impedance amp.

For applications requiring a very high input impedance and low shunt capacitance, this amplifier should suit. It has an input impedance greater than 100MΩ with a shunt capacitance of less than a quarter of a picofarad. The 2N5485/MPF102 has a low input capacitance to start with. It is operated here as a source follower with bootstrapped gate bias resistor and drain. Gain is unity. Special construction precautions are necessary to ensure strays do not significantly degrade performance.



Tone operated switch



Audio frequency switch. Sine wave input (peak value equal to supply voltage) applied to input will cause output to go high within a certain narrow range of frequency. Response outside this range is zero.

This is a new approach to the idea of operating a switch by means of a tone, such as a whistled note. It avoids the problems of acceptor filters formed by twin-T networks in the feedback paths of op-amps. They either oscillate or fail to discriminate against loud noises pitched just outside the acceptor frequency.

Gate IC3a squares up the input waveform and triggers IC1a and IC1b on the rising edge of its pulse. IC1a produces a short pulse (approximately 20 μs) which is applied to gate IC3b.

IC1b is set to a time delay that equals the period of the accepted frequency. It forms a reference which measures the period of every cycle of the incoming signal.

IC2a is triggered on its negative edge by the output pulse of IC1b. At the desired frequency the pulse from IC2a (which is short — about 20 μs) will appear at the gate almost simultaneously with the pulse from IC1a. These two pulses overlap, causing an output pulse at the gate.

The output pulses appear at intervals of T (period of the acceptor frequency) and since IC2b is timed longer than T, it is repeatedly retriggered and its output remains high for the duration of the signal.

(Note diagrams of waveforms)

When the incoming signal is too low in frequency, pulses do not coincide at gate IC3b.

When the incoming signal is too high in frequency, IC1b is prematurely retriggered, remaining permanently high at pin 10 (Q), causing elimination of any pulse output from IC2a.

(1) Ideally, C in IC1a and IC1b should be the same value to equalise start up delay upon triggering, but with small values of C this delay is negligible.

(2) Frequency of acceptance is controlled by R and C on IC1b. Bandwidth of acceptance is controlled by R and C on IC2a.

(3) A 4011 can be used in place of the 4093 for IC3, but the latter is probably preferable.

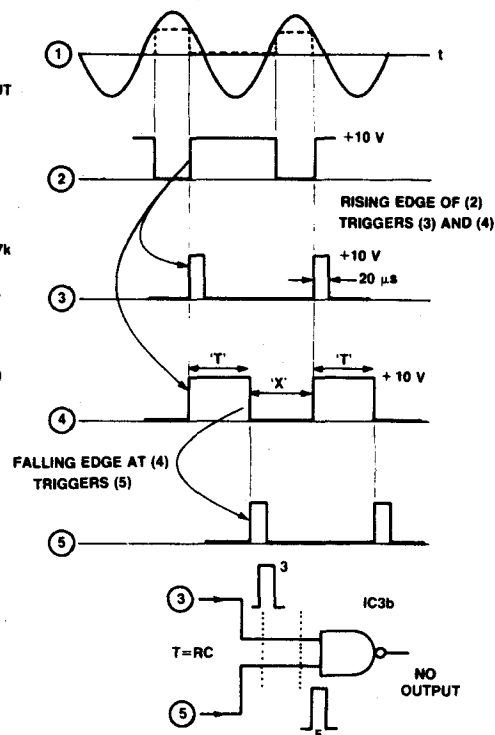
(4) ICs 1 and 2 are 4528 dual retriggerable monostables.

(5) IC2b can be connected to be positive or negative edge-triggered; it does not matter which. IC2a, however, must be negative-edge triggered.

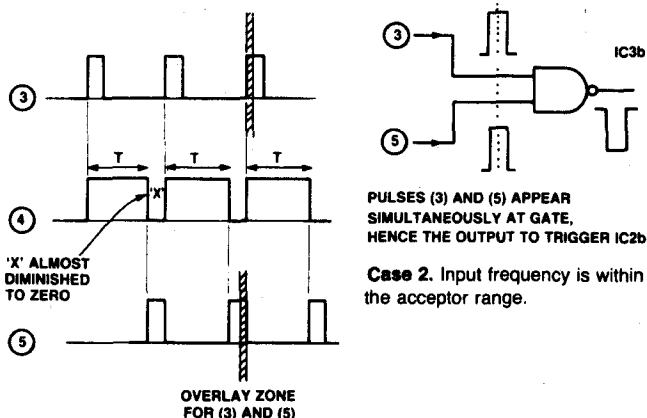
(6) The input signal should rise to a peak which is about equal to the supply voltage to ensure reliable triggering.

(7) The circuit will not trigger at one half or one quarter of the acceptor frequency.

I intend to use the circuit in a 'hands-free' whistle-switched intercom in my workshop (where I frequently have dirty hands).



Case 1. Input frequency is below the acceptor frequency



Case 3. Input frequency is higher than the acceptor frequency. IC1b is retriggered before its timed interval has elapsed. Its output is permanently high and the waveform (5) disappears. Hence no triggering of IC2b is possible.

In a breadboard assembly using two complete circuits, the values of C and R must be chosen for IC1b: low note — 1n, 1M5; high note — 1n, 1M. Cheap greencap capacitors were used. The frequencies of acceptance measured were 900 Hz and 2 kHz respectively.

This arrangement can be made to switch on to a few whistled bars of 'I did it my way', and switch off to a few bars of 'Colonel Bogie'. Needless to say, the circuit will also find use in less frivolous

applications.

When a sine wave (peak value equal to supply voltage) is applied to the input and output will go high within a certain narrow range of frequencies. Outside this range the response will be zero.

The frequency at which the circuit responds is a function of the time constant set by the capacitor and resistor on IC1b. The 'breadth' of the response range depends on the time constant set by the capacitor and resistor on IC2a.

Battery watchdog

In most equipment where there is a battery back-up, there is no indication of the condition of the battery.

The battery may lie around forgotten until it is eventually required, but then you find that it is no longer serviceable and may even have leaked corrosive acid damaging components and the pc board.

C.W. Catherwood of Lis-more NSW has designed a simple circuit which indicates a dying battery in a battery back up system. It only uses a few components and the small pc board can be easily incorporated into most equipment.

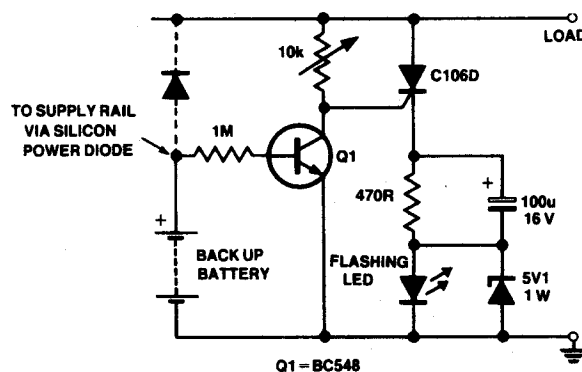
Q1 and the 10k preset potentiometer form an adjustable voltage divider. It is controlled by the

base current of Q1 via the 1M resistor and the value set on the 10k potentiometer.

The voltage on the divider feeds the gate of the SCR, switching it on. The SCR then conducts through the flashing LED, indicating an unserviceable battery.

The zener diode maintains the five volts required by the flashing LED. The electrolytic capacitor across the series dropping resistor forms an RC network which determines the flashrate.

The voltage of the battery which is to be tested can be determined by adjusting the 10k potentiometer. This could be done by using an adjustable power supply in place of the battery.



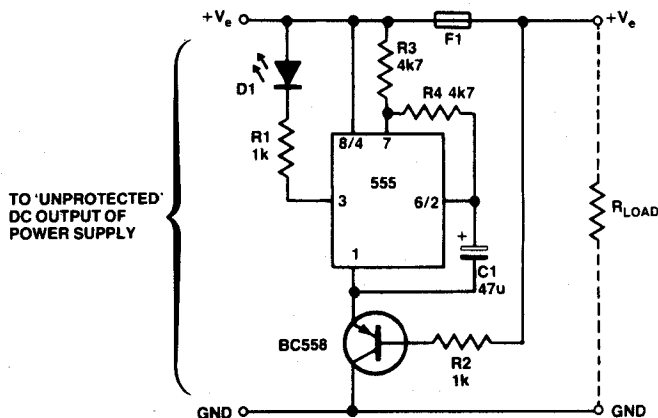
Fuse failure Indicator

R.N. Sinclair of Coogee NSW sent in this circuit which indicates an open circuit fuse by flashing the LED D1.

The circuit is based around the popular 555 timer IC which is arranged as a multivibrator with its frequency/period determined by C1, R3 and R4. R1 is the current limiter for D1.

When the fuse is intact, the BC558 is off but when the fuse fails and there is an open circuit the BC558 switches on, supplying power to the input of the 555 (pin 1). A load must be present to switch the transistor on and consequently the LED.

The fuse fail indicator must not be used when the power supply is greater than 15 V.

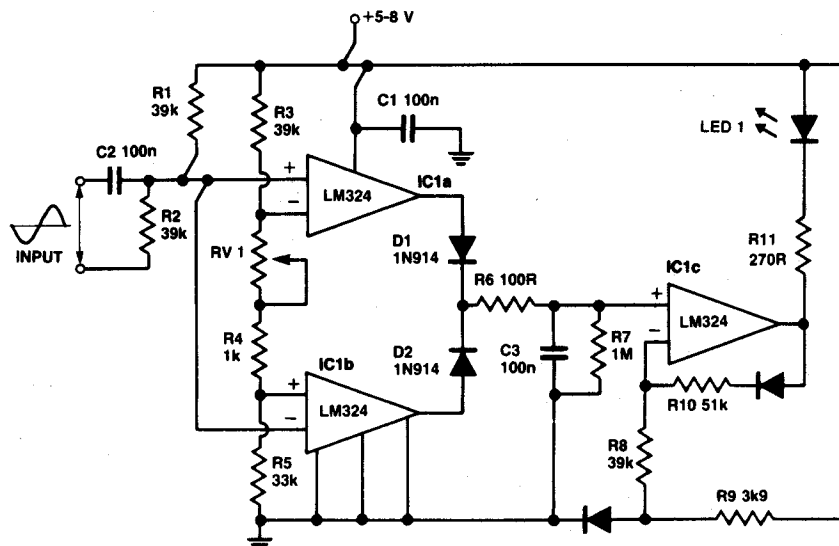


Peak level Indicator

David Hamill of The Gap, Queensland designed this peak level indicator which is useful for recording when it is more important to know what the peak level of a signal is, rather than its average level.

VU meters are normally used for this purpose, however, you will find that the LED output of this circuit is easier to interpret and makes the recording more accurate as the distortion will be reduced.

IC1a gauges the positive peaks while IC1b does the same for the negative peaks. Both positive and negative are set by RV1. You can select any threshold from ± 1 V. Whenever the input exceeds the positive of the negative level LED1 lights for about 0.1 second.



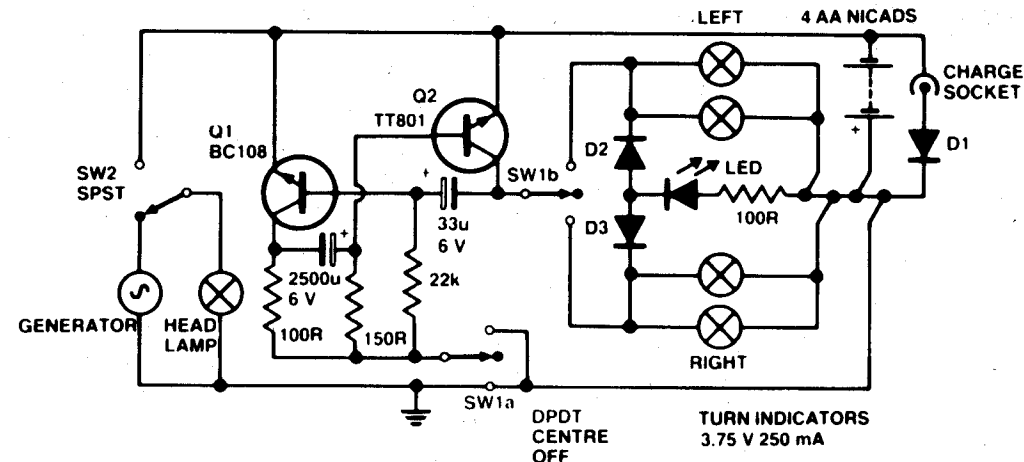
Turn indicators for a bicycle

Alec Phillips of Myrtleford Victoria found that it is quite dangerous when he is riding his push-bike at night, especially when he is approaching or waiting at an intersection in a town.

The indicator unit is powered by four AA Nickel Cadmium batteries, which are mounted, with most of the components, in a small jiffy box under the seat. S1, S2, D2, D3, the LED and 100R resistor are mounted on a small panel on the handlebars.

The purpose of S2 is solely as an added bonus to power the head and tail lights when stopped at intersections or when climbing a steep hill at low speed.

The main circuit is very simple. D1 is to prevent any short circuit in the charge socket by the plug. D1 is also necessary in case of reverse polarity. The LED shows that the indicators are on. D2 and D3 drive the LED from either the left or right-hand side.



S1 is a DPDT 'centre off' mini toggle. Q2 is a TT801 because it drives the indicators direct.

The 3.75 V, 250 mA lamps were obtained from the local cycle shop. These low voltage globes are used because the terminal voltage of the batteries is 4.8 V, less a 0.6 V loss in Q2, leaving approximately 4.2 V on a 3.75 V globe. This gives a bright flashing indicator.

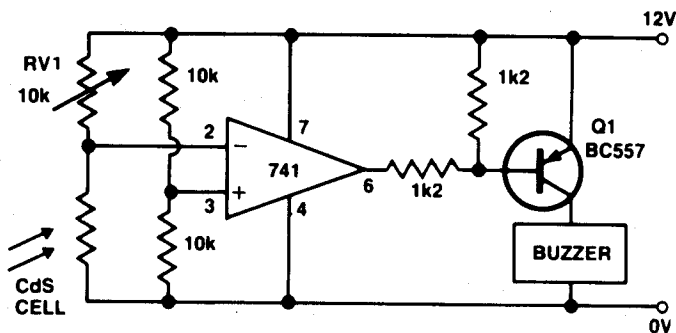
Refrigerator watcher

Ron Klein of Walgett NSW sent us this article. It's a cunning adaptation of a standard op-amp circuit, and is used to monitor the operation of a kerosine refrigerator.

The core of the circuit is a Cadmium Sulphide cell which has a sharply defined sensitivity to radiation of about 5700 Angstroms i.e.: yellow light.

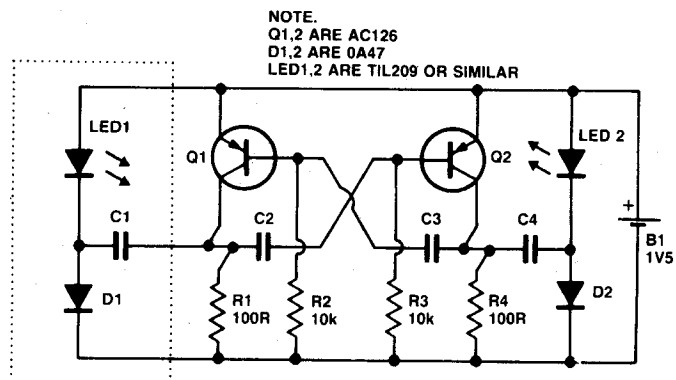
The CdS cell is aimed at the

kerosine flame of the 'fridge, via a suitable piece of tubing. When the 'fridge is operating normally, this flame will have a strong yellow colour. However, if it either flares up, or drops low, the colour changes, and with it the resistance of the CdS cell. This change of resistance is detected by the op-amp, and the buzzer triggered via the BC557.



LEDs on 1.5 V battery

As most LEDs require a forward voltage between 1.6 and 2.3 volts, it's difficult to power them from a 1.5 V battery. This circuit is an astable multivibrator and voltage doubler that boosts the voltage across the LEDs. To make the LEDs appear to be on continuously, C1 and C2 should be 47n, C3-C4 10μ. To make the LEDs flash alternately, C1-C2 should be about 100μ, C3-C4 should be about 10 times that. To operate a single LED, omit LED1, D1 and C1.



NOTE.
Q1,2 ARE AC126
D1,2 ARE 0A47
LED1,2 ARE TIL209 OR SIMILAR

Modification to battery condition indicator

Jerry Stamatelatos of St Kilda Victoria has come up with a modification for the battery condition indicator circuit which appeared in ETI Circuits No 4 on page 70.

The modification is based on the addition of three rotary switches which provide a selection of six voltages.

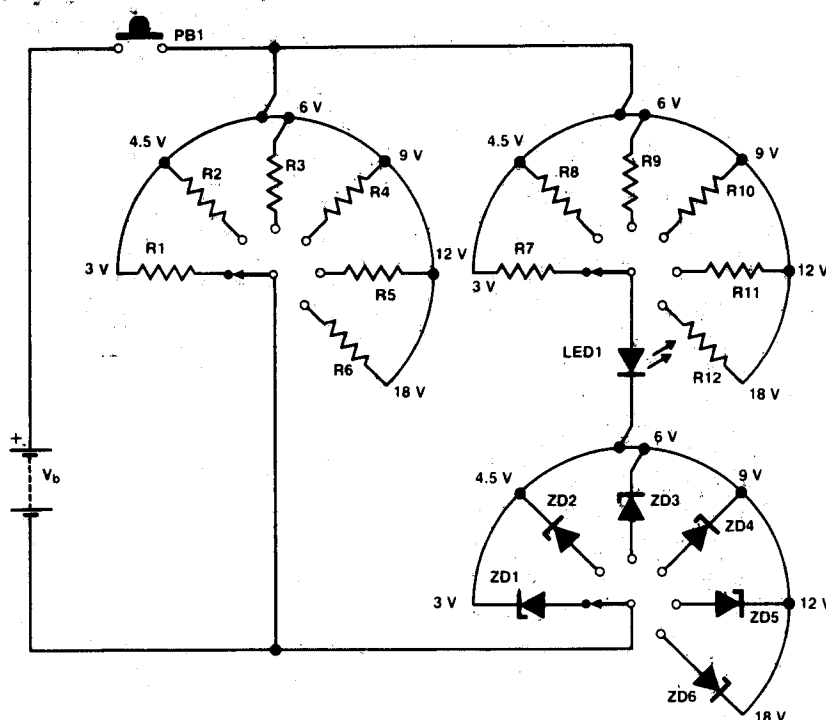
Resistors

R1	270R
R2, R12	390R
R3	470R
R4	820R
R5	1k
R6	1k5
R7	68R
R8	100R
R9	120R
R10	180R
R11	220R

Semiconductors

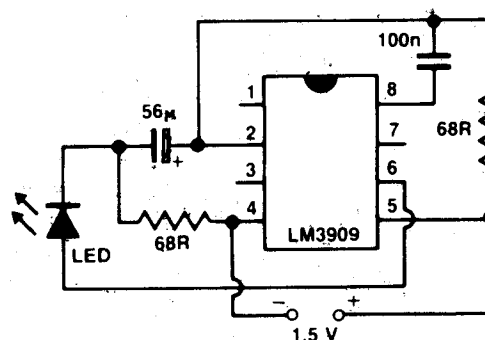
ZD1	0V7*
ZD2	2V1*
ZD3	3V3
ZD4	5V6
ZD5	8V2
ZD6	13V

*For these low zener voltages, use one or more silicon diodes in series forward biased.



LED light booster

The LM3909 LED flasher IC is used here to boost the brightness of ordinary LEDs by energizing them with high current pulses at 20 kHz or so.



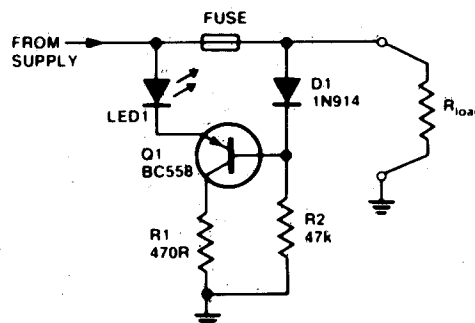
Blown fuse indicator

Fuses are probably the handiest tool in electronics in that for an outlay of cents they can save hundreds of dollars worth of equipment. When a fuse blows it is usually obvious as the equipment it supplies stops working, sometimes however this is not always the case. If the fuse supplies, for example, power to brake lights in a vehicle or even long delay timer circuits it may not be noticed for days. This circuit will give immediate indication of a blown fuse whether there is a load on the circuit or not as long as there is power.

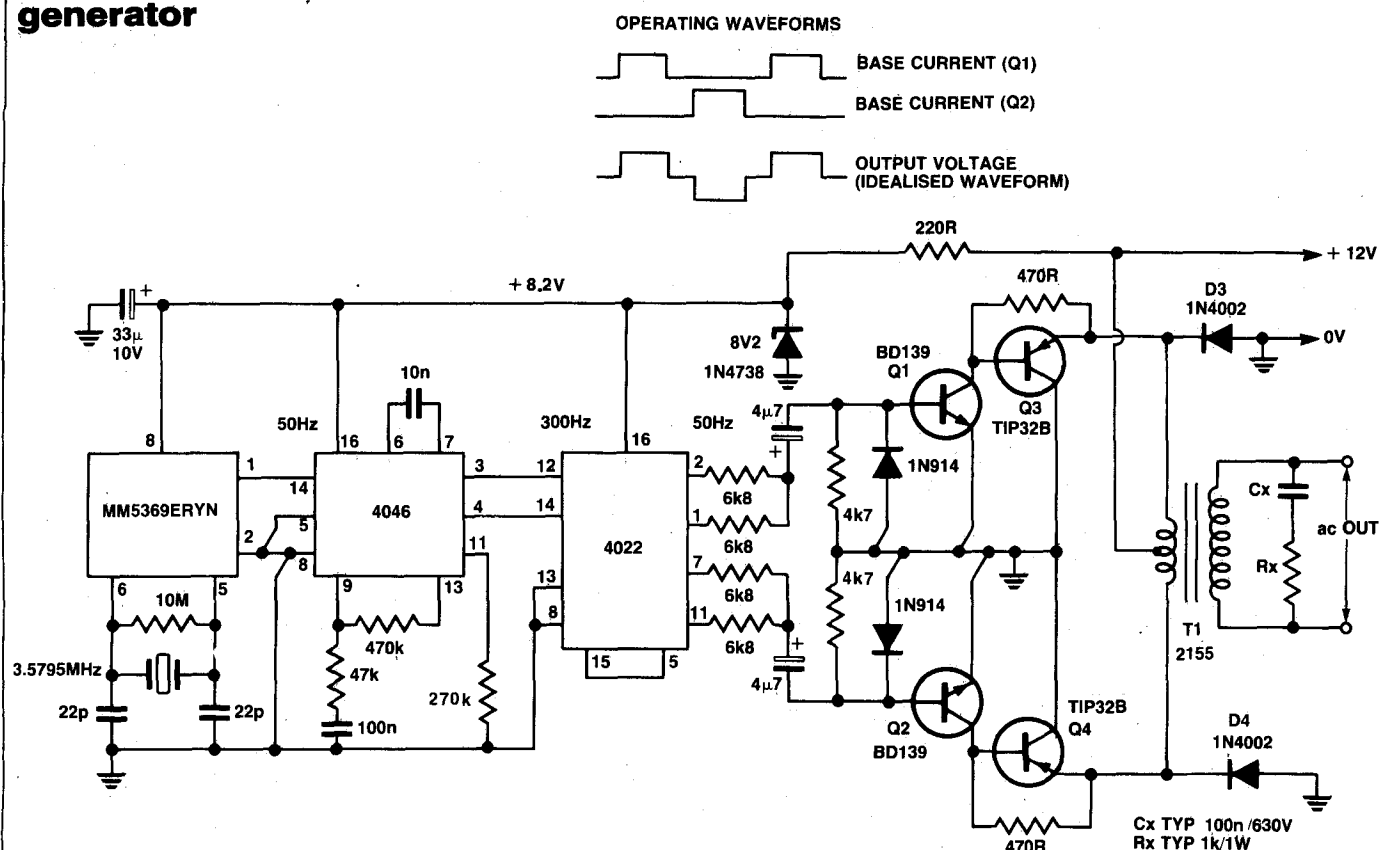
On a nominal 12 volt supply there is about a 1.7 volt drop across the LED leaving a potential of about 10.3 V on the emitter of Q1. With the fuse

intact there is a potential at the base (via fuse and D1) of about 11 V which holds Q1 off. If, however, the fuse blows, power is removed from the anode of D1 therefore allowing current to flow from the base of Q1 through R2 turning on the LED.

The advantage of this circuit is that in the standby mode it draws only 255 microamps, which makes it particularly useful in battery operated circuits. It may be adapted for different voltages by simply changing the values of R1 and R2 using the following formula: $R1 = (Vs - 2) \times 100 / 2$, $R2 = (Vs - 2) \times 10000 / 2$. (A flashing LED, which is more of an attention-getter, could be used for LED1.)



Mains frequency generator



This circuit was designed to operate a 240 V/3 W telescope drive motor but it would be suitable for many other low power applications. It could also provide the basis for a high power version, with suitable modification to the output stage.

For its present purpose, the most important requirement is for a highly stable, 50 Hz operating frequency. This is achieved by using a 3.5795 MHz crystal and an MM5369EYRN IC, which were chosen for their low cost and ready availability. The MM5369EYRN IC contains an oscillator and all the divider circuitry necessary to produce a precise 50 Hz square wave output when used in conjunction with the 3.5795 MHz crystal.

One disadvantage of this IC, however, is that its output is not an exact 50/50 duty cycle square wave. For some applications this may not matter but, if used directly to drive an output stage in a high power

converter, for example, the asymmetrical waveform could result in significant unbalanced dc currents sufficient to saturate the output transformer. Also, for high power converter applications, at least, it is desirable to drive the output transistors (usually in push-pull) with a delay between turn-off of one set of output transistors and turn-on of its complementary set of transistors.

This circuit provides both a symmetrical drive current waveform to the output transistors and the delay referred to above. This is achieved using only two low cost, easily obtainable ICs, a 4046 CMOS phase lock loop and a 4022 decade counter.

The counter is arranged in a feedback loop with the 4046 in such a way that the output is locked precisely to the 50 Hz input derived from the 5369 IC. The 4022 has, in fact, eight outputs which go sequentially high when the counter is

clocked. In this case the 4022 is connected as a divide-by-6 counter, with four of its outputs being used to supply input drive to transistors Q1, Q2. The sequential operation of the 4022 outputs is taken advantage of here to obtain the waveforms shown in the diagram without the need for any extra gating. The idealised ac output waveform has a 4:2 on/off ratio which gives a theoretical peak/rms ratio similar to that for a sine voltage waveform.

The output section is conventional. It comprises a pair of transistors Q1, Q2 in push-pull driving a pair of output transistors Q3, Q4 respectively, which in turn are coupled to an output transformer, T1. The transistors Q1, Q2 are ac coupled to the 4022 outputs, rather than dc coupled, to ensure that all the transistors are turned off in case oscillation ceases for any reason, e.g. in case of a fault.

The output transformer is a

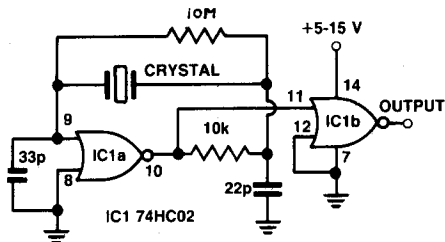
commonly available type with a 240 V/15 V centre-tapped winding ratio which, assuming a 12 V battery supplying the circuit, will theoretically give a 384 V peak (256 RMS). In practice an output closer to 360 V peak (240 V RMS) is obtained due to circuit losses.

Maximum continuous output power is around 10 W. If higher output power is required it will be necessary to substitute a suitably rated transformer and output transistors with correspondingly increased current/power ratings. It may also be necessary to use Darlington output pairs to obtain the increased output current.

Diodes D3, D4 and a series RC network across the transformer secondary minimise switching spikes in the ac output. Some experimentation with the values of C_x , R_x may be necessary for optimum suppression depending on transformer type and output loads.

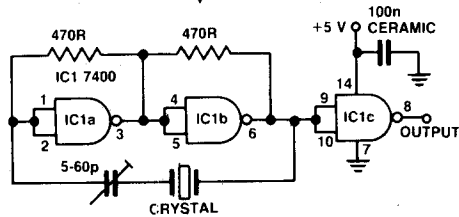
HCMOS crystal oscillator

This circuit works well with crystals in the MHz region, up to 15 MHz, perhaps more. It starts reliably and can be operated on any supply rail between 5 V and 15 V. The 22p and 33p capacitor values may need to be increased for lower frequency crystals — but maintain the ratio. ▽



Reliable TTL crystal oscillator

Many TTL crystal oscillators have been published over the years, and many exhibit unreliable oscillation — particularly on startup. This one has none of those problems. This will work with crystals in the 1 MHz to 20 MHz range as well as with 'Ceralock' ceramic resonators. The trimmer is to set the crystal to frequency, if necessary. If not, substitute a 100p-1n ceramic capacitor. ▽



Pulse generator modification

Arthur Barrett of Cartwright NSW suggested this handy addendum to our ETI-166 function/pulse generator project.

His circuit allows the frequency counter in the pulse generator to count frequencies outside the generator. The circuit uses a DPDT switch to select either an external source or the on-board frequency as the input.

The BNC output and the select switch can be mounted on the side of the cabinet. If you wish, the other side of the DPDT can be used to select between two LEDs to indicate the position of the switch.

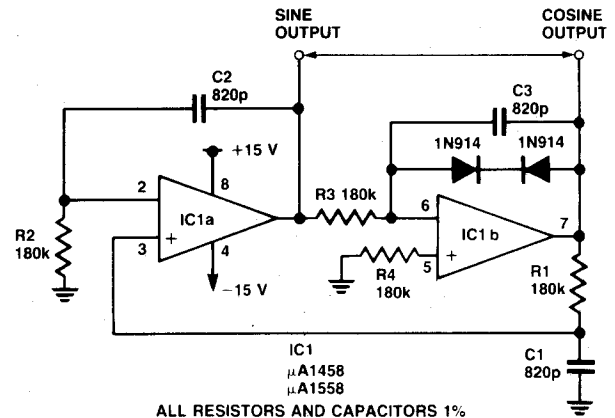
This simple circuit should save you approximately \$70 on the price of a good frequency meter. ▽

Quadrature sinusoid oscillator

This oscillator provides two sinusoid outputs precisely 90° apart. All capacitors should be 1% types. $R1C1 = R2C2$. The oscillation frequency is given by:

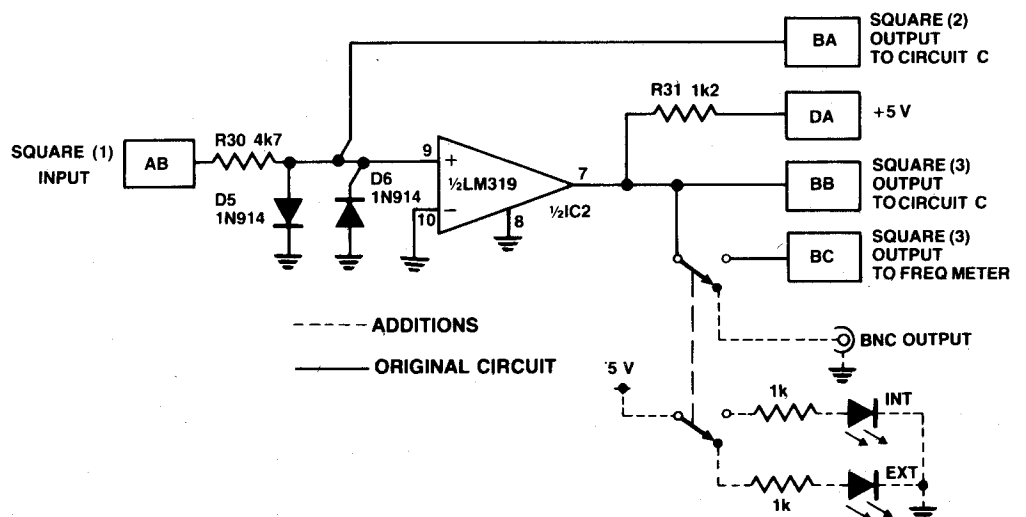
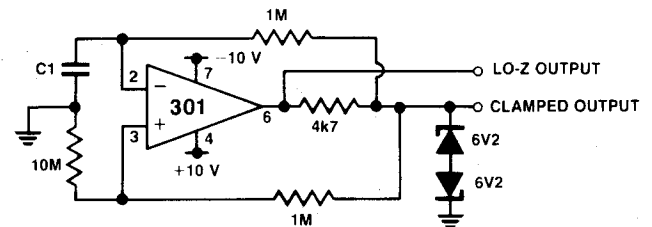
$$f = \frac{1}{2\pi \sqrt{C2R2C3R3}}$$

($R1C1 = R2C2$)



LF squarewave generator

The output frequency of this generator is determined by C1 and the 10M resistor. A low impedance output, that swings almost from rail to rail, can be taken from pin 6 of the 301, or a clamped output — limited by two 6.2 V zeners — gives a 6.8 V peak-to-peak output. Maximum supply voltage is ±18 V. ▽



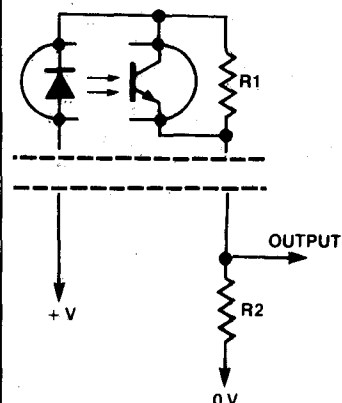
Two wires for optoswitch

Here's a simple way to run two wires instead of four to a remote opto-switch, as in the case of a wind speed indicator which provides pulses proportional to the rotational speed of a perforated disc.

An opto-coupler consisting of a

LED and a phototransistor, either of the packaged variety or made from discrete devices, normally requires four connections. However, twin-pair cable is common, cheap and convenient and it's more economical (and more elegant) to use two wires rather than four for a remote sensor. The further away the sensor may be located from the indicator, the more attractive a two-wire system becomes.

In the circuit, resistor R1 provides a 'starting' current for the LED. Current through R1 and R2 will provide a certain dc level at the output when the path between the LED and phototransistor is blocked. When the path is unblocked, the phototransistor saturates, virtually shorting out R1, thus providing more current through R2, increasing the output dc level. This change can be sensed and used as required.



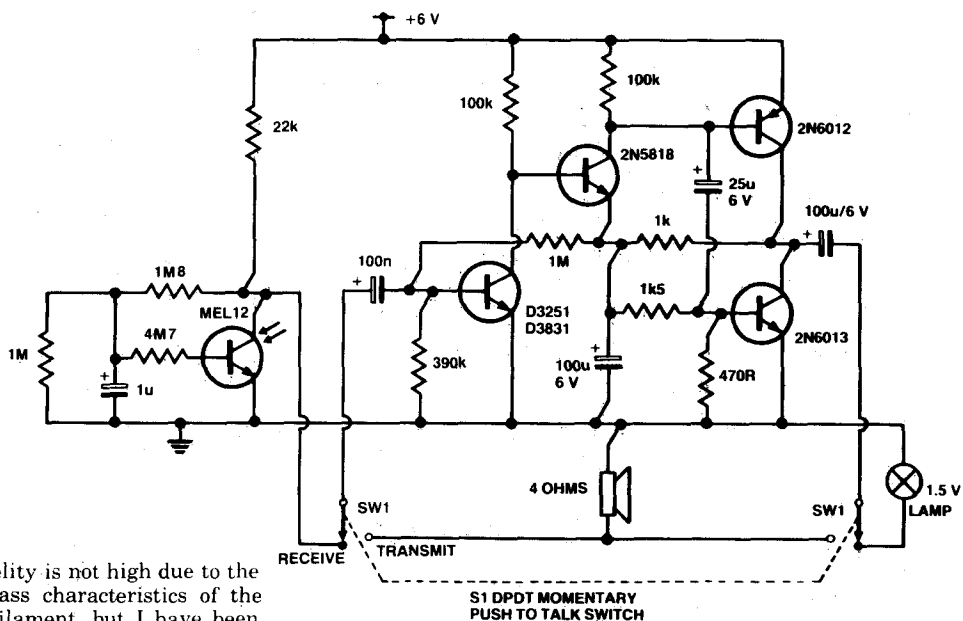
Flashlight communicator

This simple, portable, visually-aligned transceiver, designed by Chris McRae of West Pymble NSW, is quite effective and can be easily built into a flashlight.

The lamp current, modulated at an audio frequency, modulates the light beam. The light beam is detected by a photodarlington transistor and drives a small speaker for audio output.

The lamp is driven by an ac signal which cuts the RMS voltage to about one-third of the six volts, which is why a 1.5 V bulb is used in a 6 V circuit.

The photodarlington can be mounted on the axis of the beam or you may get better sensitivity by placing it so that it faces the reflector of the flashlight just above the bulb (the bulb filament is at the focal point of the reflector).



Fidelity is not high due to the low pass characteristics of the bulb filament, but I have been able to have intelligible conversations at distances up to 30 metres.

Increased range for IR systems

A simple method of increasing the range of published IR projects is to place the IR LED at the focal point of a magnifying glass, says Spencer Featherstone of Toowoomba Qld.

With a little experimentation a parallel beam of light can be produced. The diameter of the beam will depend on the diameter of the lens and, in some cases, its focal length.

In theory the beam will have a constant intensity with distance and will only be attenuated by its passage through the atmosphere. In practice it is difficult to focus

the beam this accurately. However, ranges in excess of one hundred metres are possible and this means that the IR trip relay (ETI-570) can be used as a perimeter alarm, with the aid of a few mirrors.

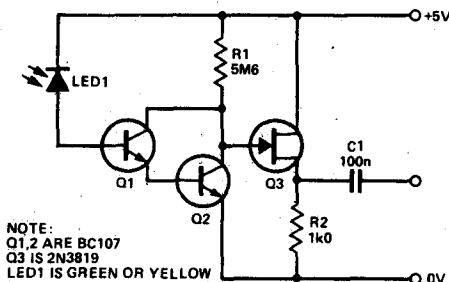
This idea can also be applied to the IR remote control system (ETI-599). In this case it would be better to place the IR LEDs just inside the focal point of the lens to create a slightly divergent beam. While this will limit the maximum range, it will make the transmitter easier to aim over long distances.

Cheap photodiodes

This circuit was evolved using an LED in place of a photodiode. Diode D1 can be any run-of-the-mill green or yellow LED. Red LEDs are not suitable.

When the light source to D1 is

interrupted, its reverse leakage current decreases sufficiently to cause the Darlington pair Q1, Q2 to switch off. This in turn causes the FET to conduct giving a pulse at the output.



NOTE:
Q1,2 ARE BC107
Q3 IS 2N3819
LED1 IS GREEN OR YELLOW

Triggered flash unit

By triggering an electronic flashgun using a sound operated switch, photographs of such things as a balloon bursting, the cork leaving a champagne bottle and objects splashing into water can be taken. Since electronic flashguns normally give an effective shutter speed of around a 1000th of a second, a "frozen" action photograph is obtained.

The photograph must be taken under fairly dark conditions so that the ambient light does not give an exposure if the camera's shutter is set to "B" and opened.

The circuit is based on operational amplifier IC1 which is used in the non-inverting amplifier mode. R1,2 are a negative feedback network which set the gain of the unit at about 500. RV1 (sensitivity) biases the non-inverting input to the negative supply rail. Ideally the input should be fed from a crystal or high impedance dynamic microphone, but the

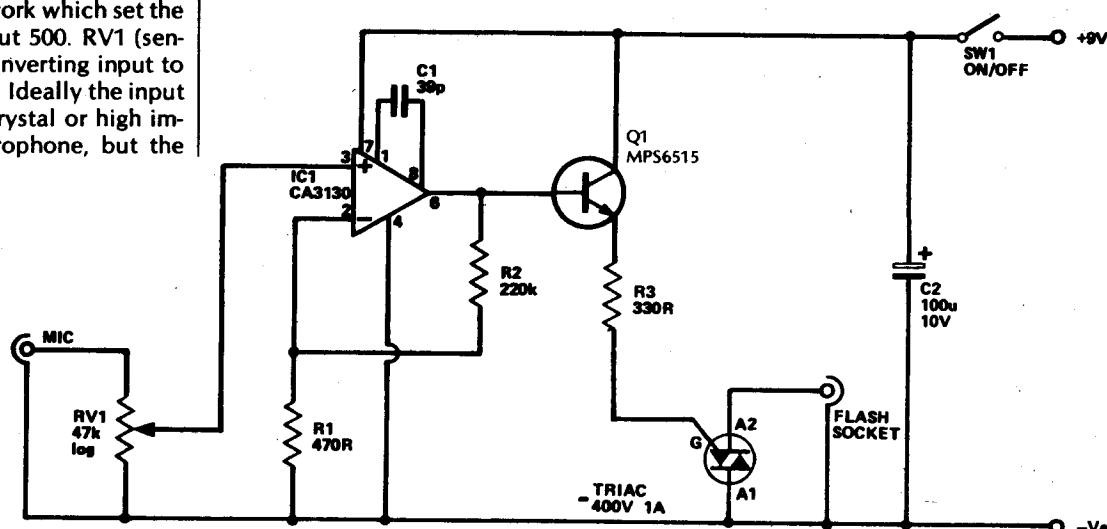
via a suitable socket (or flash extension lead with the unwanted plug removed) and the flashgun is, therefore, fired. The circuit operates almost instantly, giving very little delay between the commencement of the sound and the flashgun being triggered. Sometimes more interesting photographs can be obtained by introducing a small delay.

This can be achieved by moving the microphone a metre or two away from the object(s) being photographed.

The current consumption of the unit is approximately 4 mA. It is advisable not to advance RV1 much more than is absolutely necessary in order to give reliable triggering, as frequent spurious operation of the unit could otherwise result.

unit will work quite well using a low impedance dynamic microphone or even a high impedance speaker as the signal source.

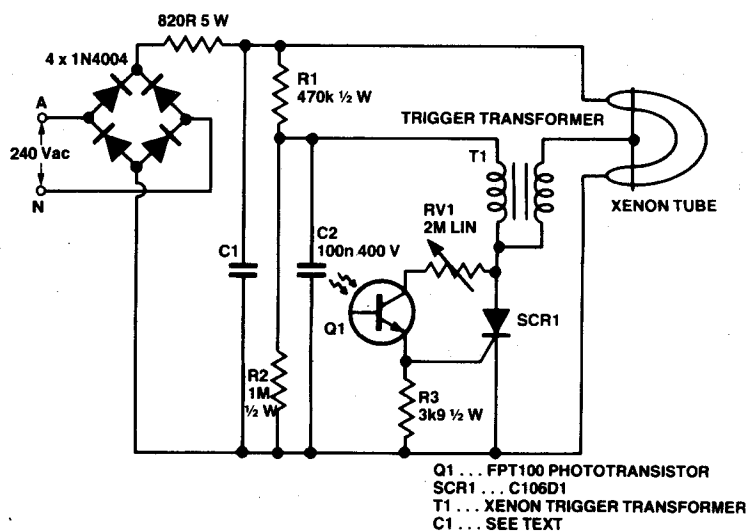
Q1 is used as a discrete emitter follower output stage which provides the relatively high trigger current required by the triac. R3 is a current limiting resistor. Under quiescent conditions the output of IC1 will be at virtually negative supply potential, and the triac, therefore, receives no gate current. When a signal is received by the microphone, positive going signals are amplified by IC1 to give an output that is a few volts positive. The triac then receives a strong gate bias, causing it to trigger and give a low resistance across its A1 and A2 terminals. These terminals connect to the flashlead



Inexpensive slave flash

Geoff Condict of Tarnagulla Vic. has come up with an idea for a slave flash which he claims is much more powerful than cheap flashguns which amateur photographers buy for bounce and side lighting in studio shots.

Since LASCR's are difficult to obtain these days, the circuit uses a phototransistor to turn on the SCR when the light from the master flash impinges upon it. The 2M pot in series with the phototransistor is used to set the unit's sensitivity. C1 is the main flash capacitor and the larger its capacitance, the brighter the flash. It's value should be between 200u and 1000u at 400 Vdc to give an extremely bright flash. Capacitors of this size may frequently be found in a discarded black and white TV chassis.



Low drop-out voltage regulator

I NEEDED a voltage regulator with very low dropout voltage, capable of supplying 5 V at about 3 A. Since many three-terminal regulators have a dropout of 2.5 V or more, the circuit described here was devised using discrete components.

Although very simple, its performance was found to be comparable to that of IC regulators. The circuit of my prototype is shown in Figure 1, and it gave the following results:

Dropout voltage (@ 3 A)	0.75 V
Load Regulation (0-3 A)	less than 10 mV
Line regulation (Vin 6 — 15 V)	less than 10 mV
Ripple rejection (@ 3 A)	-63 dB
Output (no load)	4.96 V

Changes in the output voltage due to ambient temperature variations will be entirely dependent on the characteristics of the zener diode, ZD1 and transistor Q3. Thus, these should be kept clear of heat producing sources, e.g.: the heatsink for Q1 and the power transformer.

The circuit, as it stands, has no well-defined current limit, but this feature can be included with the addition of the components shown in Figure 2. Doing this, however, causes the dropout voltage to increase by 0.5 V. An alternative method of providing current limit without increasing the dropout voltage is to load the output to the required maximum output current and gradually increase the value of the resistor R1 until the output voltage just starts to drop. The disadvantage with this method is that R1 must be selected on test and will need to be re-adjusted if Q1 is ever replaced. Thus, if current limit is desired and a slight increase in dropout voltage can be tolerated, the method shown in Figure 2 is the preferred one.

Another characteristic of the circuit is that, should a heavy load cause the output voltage to drop below approximately 1.2 V, the regulator will automatically shut itself off and can be restarted by removing the input voltage (or switching off at the mains), waiting several seconds, and then re-applying power. Merely removing the load will not allow a restart.

Components C1 and D1 are the startup components and allow reliable starts even with heavily capacitive loads. In order that the circuit may be adapted for any voltage and current (up to about 5 A), the following simplified design procedure is given.

- (1) Select the output voltage, V_o (5 V)
- (2) Select the maximum current, I_o (3 A)
- (3) Select a suitable transistor for Q1 (TIP2955 70 V, 10 A)
- (4) $R1 \text{ max.} = V_o / (I_o / h_{FE \text{ min}} Q1) = 5 / (3 / 20) = 33.3$
use 33R

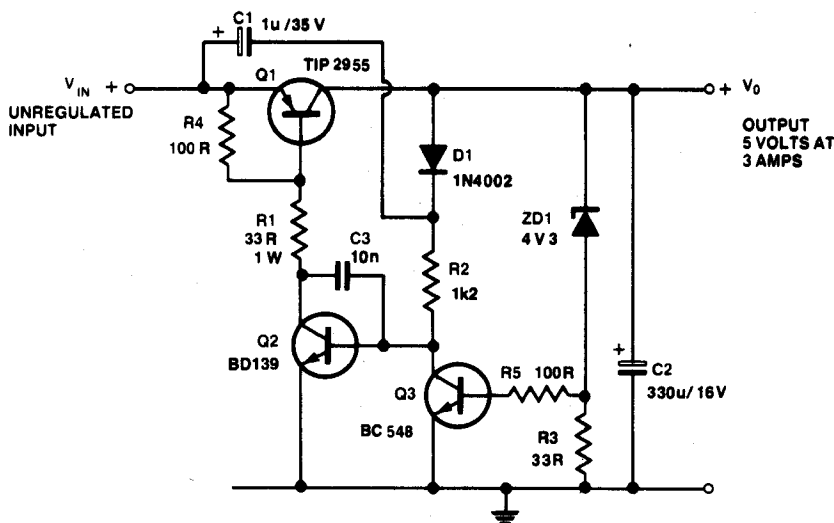


Figure 1. Circuit of the low dropout regulator. Design information is given so that the circuit can be arranged for other voltages.

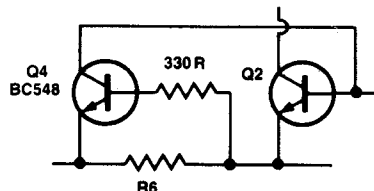


Figure 2. Adding current limit.

- (5) Dissipation of $R1 = V_o^2 / R1 = 25 / 33 = 0.75 \text{ W}$ (use 1 W)
- (6) Select a suitable device for Q2 (BD139 80 V, 1 A)
- (7) $R2 \text{ max.} = V_o / (I_{oh} / h_{FE \text{ min}} Q1 \times h_{FE \text{ min}} Q2) = 5 / (3 / 20 \times 40) = 1300$
use 1k2
- (8) Dissipation of $R2 = V_o^2 / R2 = 25 / 1200 = 21 \text{ mW}$ (use 1/4 W)
- (9) Select a suitable device for Q3 (BC548 25 V, 100 mA)
- (10) Select a suitable zener diode, ZD1.
Voltage = $V_o - V_{be}(Q3) = 5 - 0.65 = 4.35 \text{ V}$ (use 4V3 zener)

As the current flowing in Q3's base will usually be very small, it may be ignored. Thus, a low wattage, 400 mW or 1 W, zener may be used.

R3 should be chosen to bias the zener well into its operating region. A good rule of thumb is to select the current through the zener (I_z) to be a fifth of its maximum.

$$R3 = V_{be}(Q3) / I_z$$

$$I_z = 0.2 \times (P_z / V_z) \quad (P_z = \text{zener power, } V_z = \text{zener voltage})$$

$$= 0.2 \times (0.4 / 4.3) \text{ assuming } 400 \text{ mW zener}$$

$$= 18.6 \text{ mA.}$$

$$\text{Thus, } R3 = 0.65 \text{ V} / 18.6 \text{ mA}$$

$$= 35 \text{ ohms (use } 33\text{R, } 1/4 \text{ W)}$$

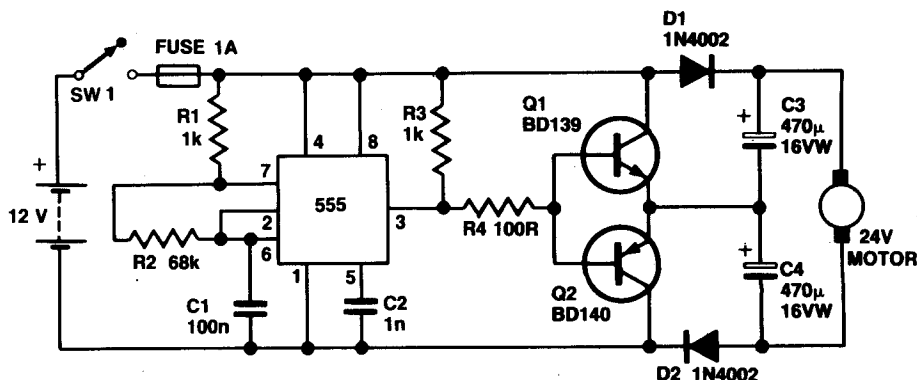
- (11) R4 ensures Q1 is not turned on by leakage. Its value is not critical. 100 ohm, 1/4 W is usually suitable here.
- (12) R5 is used as a precaution, preventing excessive current through Q3's base; 100 ohms is suitable.
- (13) C1 is the startup capacitor. Any value between 1u and 4u7 should be satisfactory. Its voltage rating should exceed V_{in} .
- (14) C2 should always be used for stability. A value of 100u per amp of load current is suitable. 330u was used in the prototype. Its voltage rating should exceed the output voltage rating.
- (15) C3 is required for stability. 10n should suit.
- (16) Mount Q1 on a suitable heatsink, according to the power it dissipates. (This should be low if $V_{in} - V_{out}$ is low).

Transformer-less voltage doubler

This circuit shows a convenient method of supplying a 24 V motor from a 12 V battery.

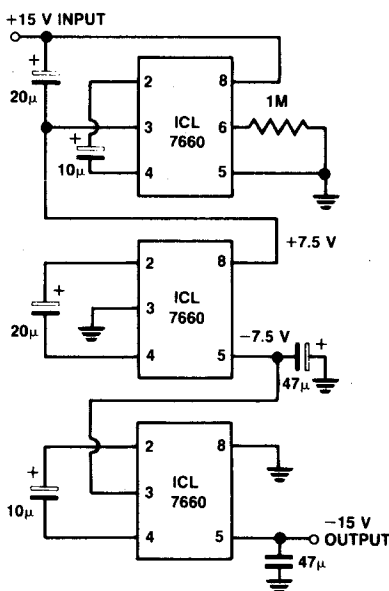
The 555 timer operates in astable mode to produce a square wave at about 1 kHz. When pin 3 of the 555 goes high Q1 conducts and charges C4 to just under 12 V, whilst D1 prevents C3 from discharging. When pin 3 goes low Q2 conducts and similarly charges C3, while D2 prevents the discharge of C4.

The resultant voltage across C3 and C4 supplies the motor. Output is around 22 V with no load, dropping to about 20 V with a motor drawing its maximum of 200 mA. The transistors should be heat sunk.



+ 15 V to -15 V supply rail

Cascading three 7660 positive-to-negative rail inverters to obtain -15 V from a +15 V supply. Output impedance is about 250 ohms — hence output current is limited.



Economical high voltage low current dc-to-dc inverter

Alec Phillips of Myrtleford Victoria designed this circuit, without a special inverter transformer, when he needed a high dc voltage from a low dc voltage supply. It cost him about \$7.

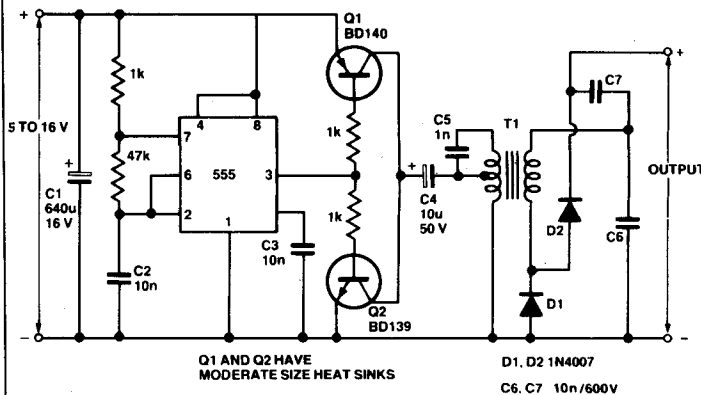
The 555 IC drives Q1 and Q2 alternately, Q1 charging via the transformer and Q2 discharging C4 into the transformer. C5 reduces power consumption and increases the output voltage. The

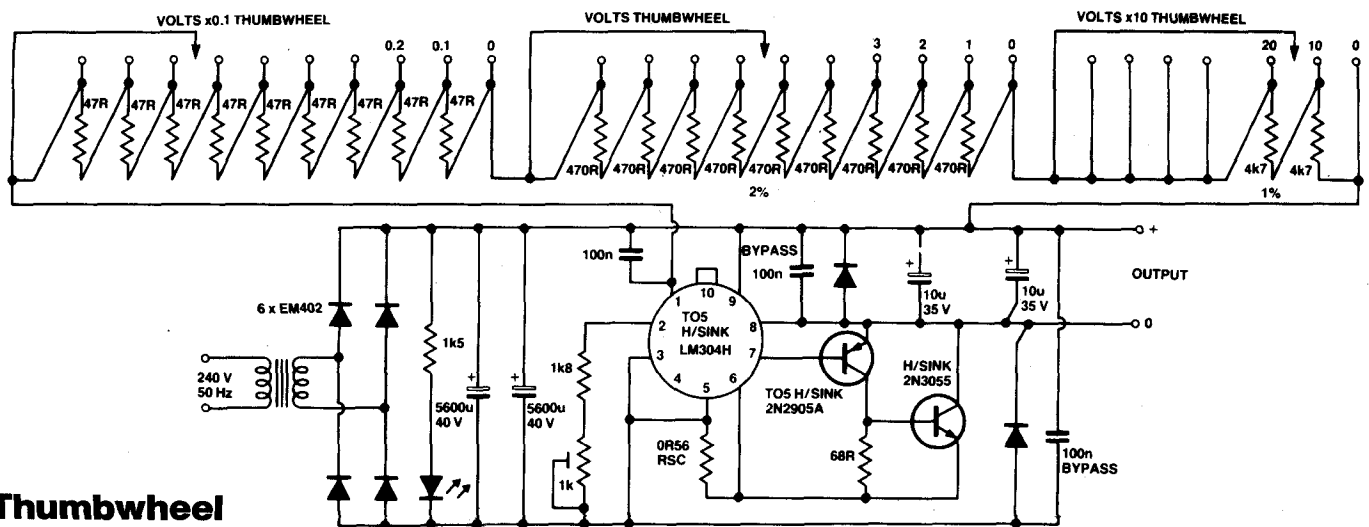
output is fed into a voltage doubler and, with a 15 Vdc supply, the output can exceed 600 V. D1 and D2 must be 1 kV, 1 A diodes.

The transformer is a 12.6-0-12.6 V, 150 mA type. The oscillator drives the centre tap of the primary low voltage winding and the output is from the 240 V end.

Q1 and Q2 must be on a heat-sink of moderate size.

If higher output voltages are required, just add more voltage doublers, but obviously it will handle a smaller load on the output. The circuit will operate at input voltages ranging from 5 to 16 volts.





Thumbwheel power supply

Most power supplies take time to use because the voltage and current limits have to be set individually. This supply, from L.W. Brown of Burwood, Victoria, is easy to use, as the current limit is fixed and the voltage is adjusted by dialling the value on thumbwheels.

It is not necessary to have a voltmeter or ammeter on this power supply, although an ammeter could be added in series with the current limit resistor (RSC) to reduce any voltage drop problems. Almost any moving coil movement can be used for the ammeter if RSC is used as the meter shunt and a preset pot in series with the meter is used to set a useful scale value.

Two per cent resistors were used for the unit volts divider, and 1% values for the tens divider. If close tolerance resistors are difficult to obtain, it may be possible to select some from a batch of 5% types with a multimeter. The actual resistance value is not critical, but the ratio of these resistors is important. The final voltage adjustment should be achieved with a good multimeter and a near full-scale voltage.

If the decimal thumbwheels are not suitable, an alternative would be a clockface multiturn potentiometer — but these are expensive.

The LM304H is a negative adjustable regulator. Two external transistors increase the output current to over 2 A; output currents of 4 A are possible if transistors with a larger power dissipation and a better than average current gain are used. The maximum input voltage is 40 V, giving a usable output voltage of 0-30 V. This regulator

is unusual in that it uses resistor voltage programming. Each additional 500 ohm resistor in series between pin 1 and the positive supply (pin 9) will produce an additional 1 V at the output.

The adjustable resistor between pin 2 and the negative supply provides some trimming, so realistic values of resistors can be used. The resistor RSC sets the current limit. The LM304H has a transistor junction across RSC, and when this conducts the regulator begins to current-limit.

I have provided a table to enable personal customising of the circuit. Some people will need particular voltage ranges; others will only have certain transformers available to optimise the circuit.

My first prototype used three thumbwheels side by side, with individual wiring back to the pc board. The range of the power supply was 0-29.9 V at 3 A. The power transistor (better than a 2N3055) was mounted on a chunky heatsink, in turn mounted on the outside rear of the apparatus. A popular transformer for amplifiers, the M0148, was used, as it is rated at 26-0-26 at 2 A. As this was a centre-tapped winding the

two upper diodes were eliminated and the CT connected to the upper positive rail.

A simpler version of the power supply was then constructed, with the output range of 0-19.9 V at 1 A. The output transistor, a 2N3055, was mounted on the pc board with two sheets of 1.5 mm, aluminium folded to form a heatsink. One thumbwheel was used for the units and another for the tenths. A slide switch took the place of the tens thumbwheel. The thumbwheels were mounted vertically above each other and mounted flat on the pc board; the only wiring used was the two wires for the output and the power transformer connections.

The one critical component was the output capacitor. I finally used two 10uF 35 V tag tantalum caps and a 2u2 green-cap in parallel. An unusual feature is that a TO5 top-hat type of heatsink is necessary on both the LM304H and the 2N2905. This heatsink improves power dissipation, but more importantly the reduced temperature improves both voltage and current limit stability. The current limit varies markedly with temperature because of the simple control circuit used in the LM304H.

Table of optional ranges

Voltage Range Vdc	Transformer secondary voltage — Vac	Number of thumbwheels	Actual voltage range
10	12	2	0-9.9
20	18	2+1 switch or 3	0-19.9
30	27	3	0-29.9

Current range — A	RSC ohm	Output transistor type	Number of filter caps	Transformer current — Aac	Heatsink	Diode rating Adc
1	0.56	2N3055	1	1.5	On pcb	1
2	0.33	2N3055	1	3.0	Large — on pcb	1
3	0.22	2N3771	2	4.5	On case rear	3
4	0.15	MJ15003	3	6.0	Large — on case rear	6

Sophisticated five volt supply

This supply will deliver up to 6 A at +5 V. It has an active overvoltage clamp on the output. Current is limited at around 6 A and has foldback short-circuit protection.

Transient suppressor S1 protects against high voltage transients (studies have shown spikes of 5 kV to be common on domestic mains supplies), and C1, R1 cut down on switch arcing when the supply is switched off. R2 is a bleed resistor which prevents the output staying high after the unit is switched off.

Q2 is the pass resistor and is switched on by R3 when more than 100 mA is drawn from the supply. Q1 and Q3 provide current limiting. When current through R7 is 6 A, the voltage on the base/emitter junction of Q3 is given by

take in equation

$$= 0.58 \text{ V for the values shown.}$$

Thus Q3 begins to conduct, switching on Q1, which increases the base voltage of Q2, thus limiting the current.

This arrangement also provides foldback limiting. If we consider the output shorted, the voltage at the base of Q3 will be about 0.6 V; thus the voltage at the collector of Q2 is approximately

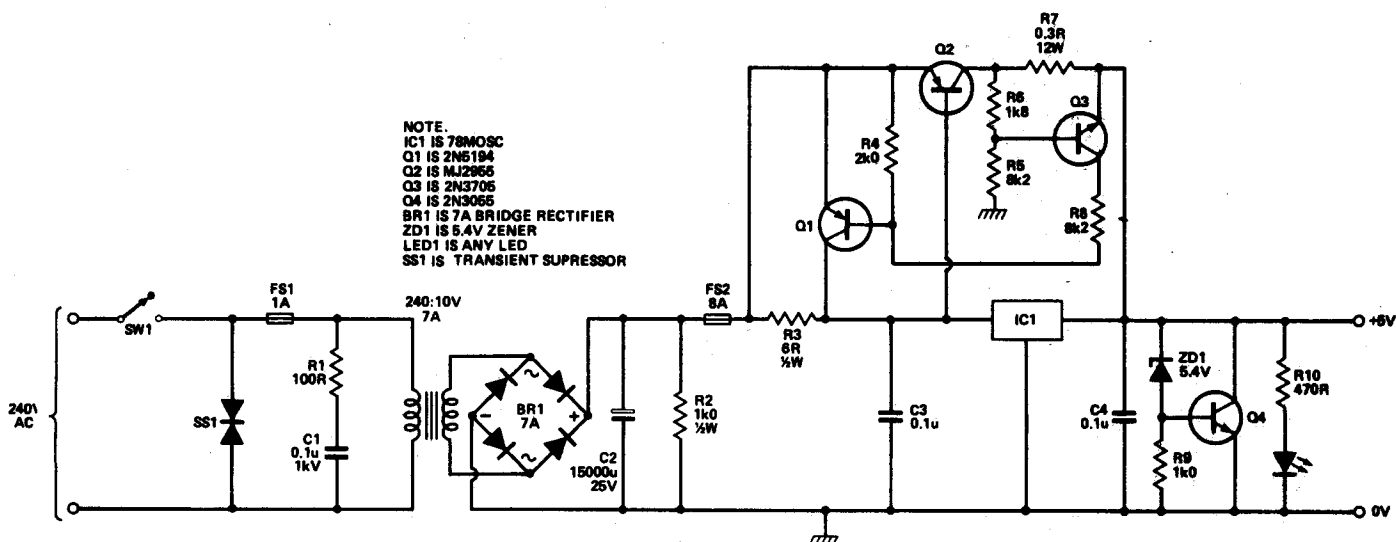
$$V = 0.6(R6 + R5)/R5 \\ = 0.7 \text{ V}$$

thus the current applied will be 2.3 A. The

foldback current may be changed by altering R5, R6 and R7. This has been set high to ensure the supply starts up under heavy loads.

Z1, R9, and Q4 provide an active overvoltage clamp. When the output voltage rises above the zener drop plus the switch-on voltage for Q4, the latter conducts. This circuit can sink 15 A continuously (properly heat-sinked) with a much higher peak current. This arrangement ensures the fuse blows before the protection circuit and guards against the common power supply problem of pass transistors failing with the collector/emitter junction shorted.

Note that Q1, Q2, and Q3 should all be mounted on heat sinks, and Q1 must be capable of passing the maximum output current of the 78M05 (500 mA).



Simple Variable Power Supply

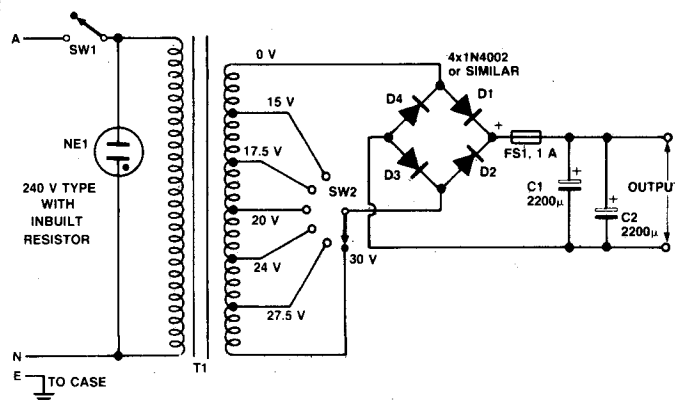
David Tindall of Doncaster Victoria, 15 years old, designed this simple circuit which he has found very useful.

I think it will appeal to beginners and enthusiasts of my own age.

SW1 is an on/off switch and NE1 is used to indicate what state the power supply is in. T1 steps down the 240 V to six different voltages. Each 'tap' on

the transformer (except 0 V) is connected to SW2. SW2 selects one of the six voltages.

The rectifier bridge is made up of four 1N4002 diodes (or similar). Capacitors C1 and C2 are provided to filter the ac ripple which is present. The fuse should be no more than 1 A; when the transformer I used is overloaded it has a nasty habit of becoming very hot.



Nicad charger

T. J. Threlfall of West Perth, WA designed this circuit to prevent accidental overcharge of nickel-cadmium cells when using a really fast charge.

I'm interested in racing 1/12th scale electric radio-controlled model cars. These cars use 6x 1.0 Ah cells and will run for ten minutes or so at an average current drain of 5-6 A. The usual method of recharging is via a 0.5 ohm resistive lead set from a 12 V car battery, average 4 A, for 15 minutes if it is initially fully discharged. A good working rule is 1.5 minutes charge for every one minute running time.

But accidents can happen and even using a timed charger does not prevent disasters as the period can be set for too long a time.

A General Electric handbook on its range of rechargeable batteries shows voltage/time curves for constant-current charging at various rates.

Figure 1 shows the general form of these curves. A curve plotted for my specific situation is shown in Figure 2. In both cases the cell voltage is shown to reach a peak soon after the cell is fully charged, and then cell voltage decreases.

A crude peak detector of the type shown in Figure 3 can be used to turn off a charger soon after the peak voltage is reached. The cells get slightly warm but not hot. Considering the price of batteries, this is a cheap way of doing it.

PB1 discharges C1 to enable the 741 to set, turning on Q1 and the relay when PB2 is depressed. PB1 and PB2 are momentary 'push-to-make' switches. Box A contains either resistive lead or any other current limiting device. C1 is a tantalum low-leakage capacitor. The diodes should be chosen so that the circuit is stable when the relay is on.

To test the circuit disconnect point B from the relay contact, connect B to a potentiometer between the +12 V and 0 V rails to see what voltage change is needed to switch off the relay.

The entire circuit shown in Figure 4 may be more relevant to a radio-controlled model, but the switching section should be of interest to those people who built the ETI-563 charger.

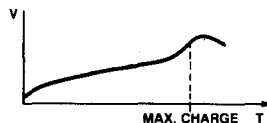


Figure 1. General form of voltage/time curve for NiCd cells, constant current charging.

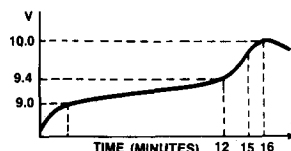


Figure 2. Voltage/time curve charging 6x1.0 Ah NiCd cells at 4 A.

How it works

The charger has two outputs. An unswitched 120 mA constant current output through Q4 is for keeping a radio-controlled transmitter, fitted with 8 AA size Nicads, topped up. The associated red LED indicates current is flowing through the leads (it will still light on a short circuit).

The second pair of output terminals supplies either 4 A (timer and relay on), 115 mA (timer and relay off) or nothing (relay off but timer still on). Q2, for the 4 A supply, is a high-gain PNP transistor. This was used to avoid the extra voltage drop of a

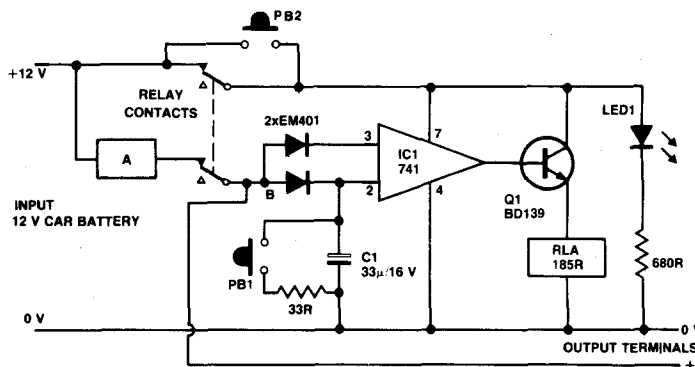


Figure 3. Crude peak detector.

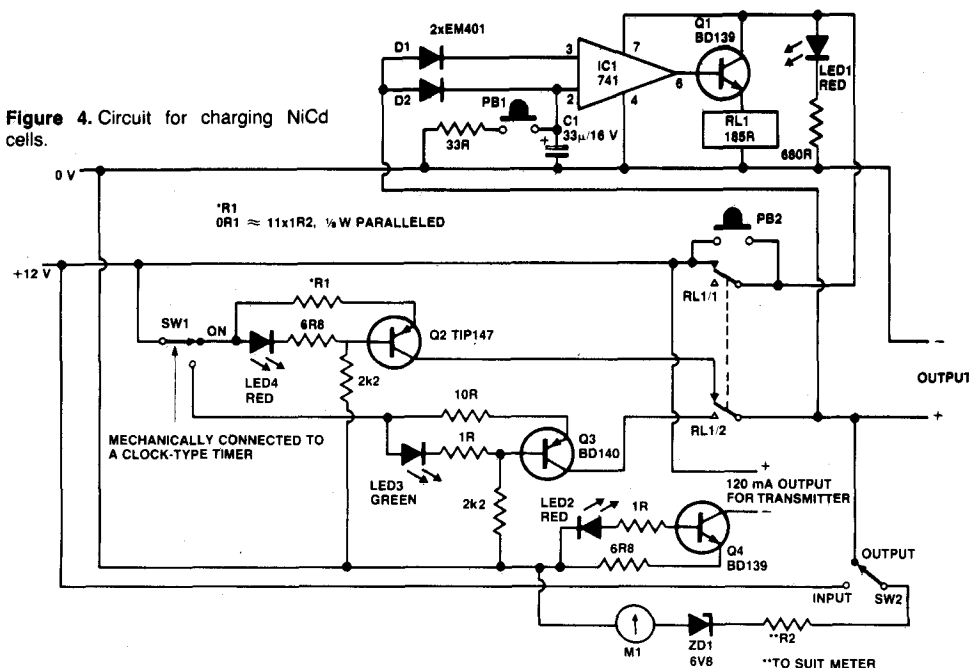


Figure 4. Circuit for charging NiCd cells.

Nicad charger (contd)

Darlington pair which would restrict the output capability when the load of six sub-C size Nicads rises to about 10.5 V.

LEDs in the base leads of Q2 and Q3 indicate current flow in the output leads. Red indicates high current is flowing through the load, green shows a slow charging of the load, while neither LED alight indicates the protection circuit IC1 has switched the relay off while the timer is still on.

The timer used is a 0-60 minute clock-type kitchen timer connected mechanically to a 10 A SPDT microswitch with an extended paddle (as the timer was not strong enough to pull the switch reliably with the

standard paddle length).

In operation, when the 12 V supply battery and the load are plugged in the green LED should light. When the timer is set for the approximate charge time required the green LED should go out.

PB2 is depressed, bypassing contacts RL1/1 and supplying power to the protection circuit. PB1 is depressed while PB2 is held down, draining C1. The relay should click on and the red LED4 should light. When PB1 and PB2 are released both LED1 and LED4 should remain on.

Meter M1 is a cheap signal meter prescaled with ZD1 and R2 to read in the range 7-12 V

fairly accurately. SW2 allows the state of the 12 V supply battery to be checked with or without a load, and monitors the voltage rise of the load battery.

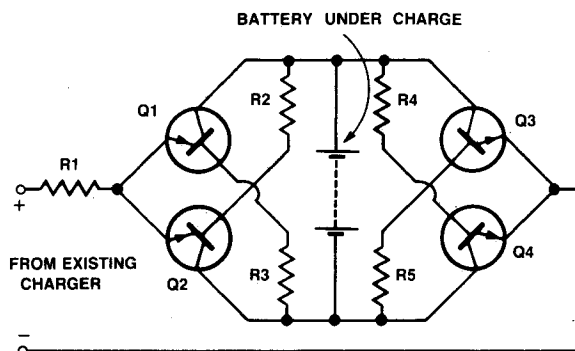
If the timer is set for too long a period, the voltage at the output terminals will reach a peak and then begin to fall (see Figures 1, 2). As the voltage falls pin 2 of IC1 will remain high. The voltage on pin 3 will drop which will cause the output on pin 6 to go low and turn off Q1 and the relay. The load batteries will drain back through the supply at 5-6 mA until the timer runs out. This is possibly of some benefit as the cells are *slightly* overcharged by the time

the relay has turned off.

The emitter-resistor of Q2, consisting of 11 x 1.2 ohm resistors, is slightly bulky and could be substituted by a piece of thin hookup wire if it can handle the current.

The current output of this section of the circuit is not constant, varying from 5 A into a completely-discharged load to 2.5 A when the load voltage reaches its peak of about 10.5 V. As this represents a total voltage drop in the charger of only 1 V, it is important that this is not increased by substituting a Darlington pair for Q2. (The car battery used dropped to about 11.5 V at 4 A after a little use).

Nicad polarity saver



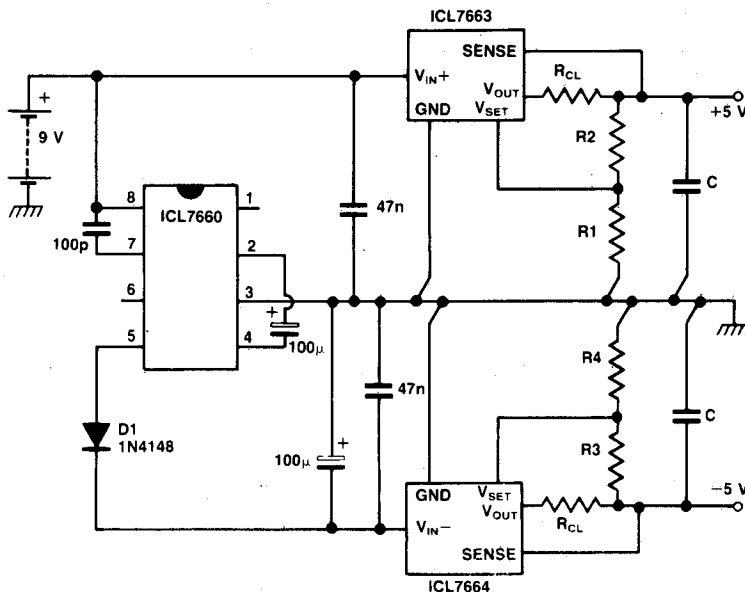
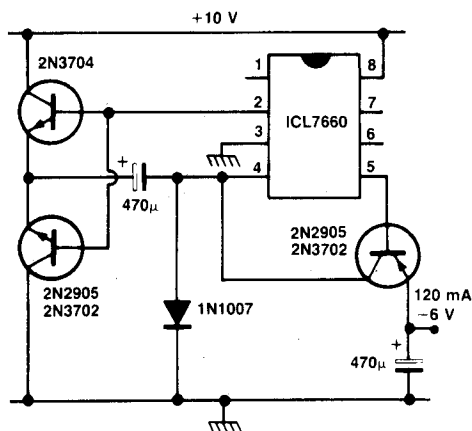
Avoid charging your Nicad batteries back-to-front — which will certainly destroy them. Residual battery potential determines the charging polarity by switching on either the pnp or npn transistors. Thus, this will not work with completely discharged Nicads. Resistor R1 is simply there for charging current limiting. If your charger has current limiting, omit R1. For a 3 V charger, R2-R5 can be around 1k8-2k2. Suitably-rated silicon transistors can be used (i.e.: TP31B). Use germanium types for single cells (1.2 V).

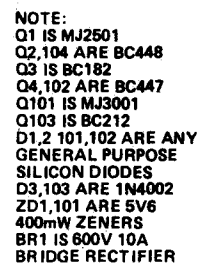
Dual 5 volt rails from 9 volt battery

A 7660 positive-to-negative rail inverter is used here in conjunction with a pair of CMOS IC regulators, a 7663 for the positive rail and a 7664 for the negative rail (all ICs from Intersil, second-sourced by Tele-dyne). These regulators draw only 3.5 μ A quiescent current but will regulate up to 40 mA output current. Output voltages are determined by the ratios of R2:R1 and R3:R4. The 47n capacitors on the regulator inputs should be ceramic types and are there to prevent instability. Circuit continues to function at battery voltages down to 6 V.

High current voltage rail inverter

The ICL7660 (TSC7660) is a positive-to-negative power supply rail inverter. It will only supply low current output though. This circuit boosts the output so that some 120 mA can be drawn from the negative rail provided by the 7660.



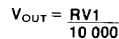


Stabilised twin power supply

This circuit will deliver up to 50 V on the two output rails at current up to 3 A. The secondary of T1 must be rated at 4.5-5 A to deliver these output currents. Full current limiting protection is provided. This circuit is ideal for use with audio power amp modules requiring supply rails up to 50 V. Note: R8 should be 47R.

50 V/1A laboratory power supply

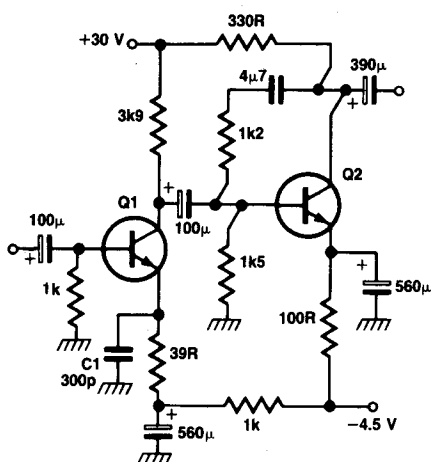
A series-pass regulator is employed here with separate circuits for voltage reference and current limiting. The input voltage should be at least 55-60 V, well filtered. The LM10 has an internal reference, which is made use of here.



Wideband amp spans 5 Hz to 30 MHz.

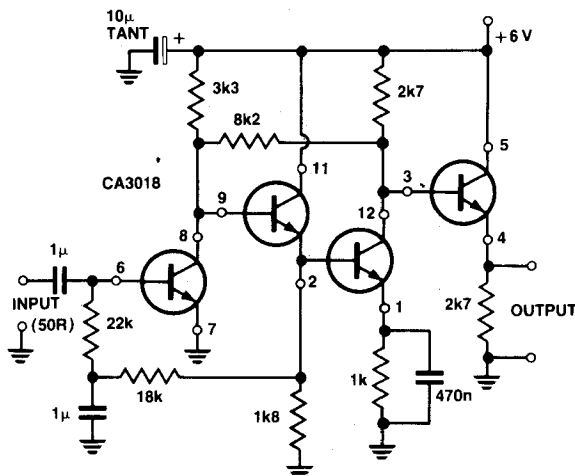
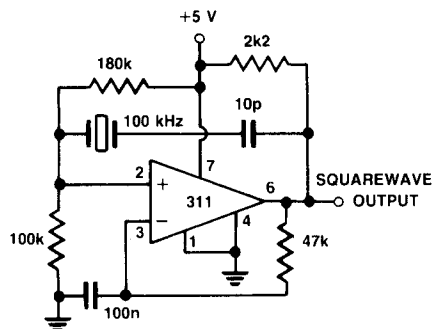
This straightforward wideband amp will deliver 6-7 volts into a 100 Ohm load over a bandwidth from 5 Hz to 30 MHz. With judicious fiddling of the value of C1, the top end rolloff may be extended to around 60 MHz. Input impedance is a few hundred Ohms. Use tantalum 100 μ capacitors throughout, not low-leakage electrolytics. The two transistors can be a variety of types: 2N3563, 2N3564, 2N2218, 2N2222, 2N5777, 2N918 etc.

WIDEBAND AMP



IC crystal oscillator

This low frequency crystal oscillator provides an essentially squarewave output. Upper frequency limit is below 10 MHz. The output voltage swings virtually from rail to rail (5 Vp-p here).

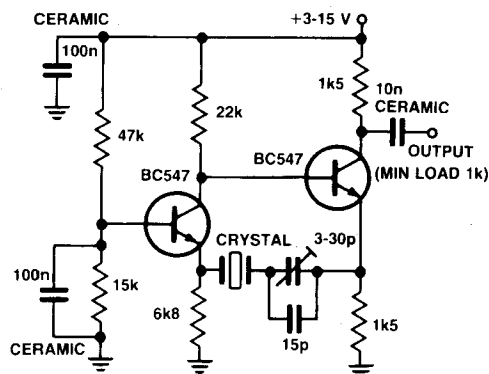


MIDBAND GAIN APPROX 50 dB
BANDWIDTH (-3 dB) 1 kHz-30 MHz.
MAX INPUT APPROX. 4 mV RMS

Wideband amp with dc feedback

For high, stable gain, a wideband amp requires several stages with multiple dc feedback paths. The two left hand and two right hand transistors here form common emitter/common collector pairs, the common collector devices providing a high impedance load for the previous transistor and a low source impedance for the following stage. This reduces internal capacitive feedback. A CA3018 transistor array IC is used. The lower cutoff is determined by the capacitor values. Use low self-inductance metallised poly low voltage types.

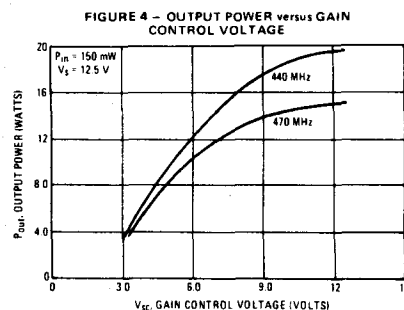
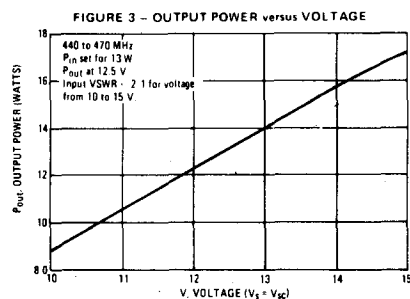
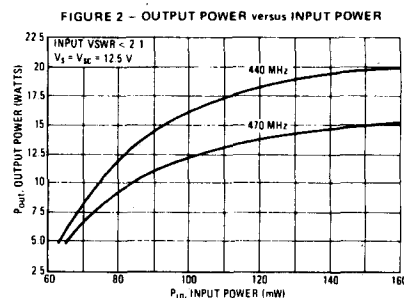
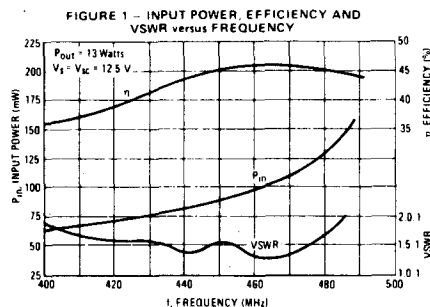
100 kHz—10 MHz crystal oscillator



This untuned crystal oscillator will operate reliably over the range from 100 kHz to 10 MHz. Output level depends on supply rail, generally around one-third (peak-to-peak). Output is basically sinewave, but you can 'square up' the output by decreasing the value of the emitter resistor of the output transistor. Dropping it to, say, 220 Ohms gives good harmonics beyond 30 MHz from a 100 kHz crystal. While BC547 transistors are recommended, many types can be used, providing their gain-bandwidth product is 250 MHz or above. e.g: 2N5777, 2N3563/4, 2N3642, 2N2222, BF115, BFY90 etc. For crystals below 100 kHz, transistors with good LF gain are recommended — such as the 2N3565. Supply voltage can range from 3 V to 15 V. The trimmer capacitor is to set the crystal on frequency if necessary. If not, use a 100pF ceramic.

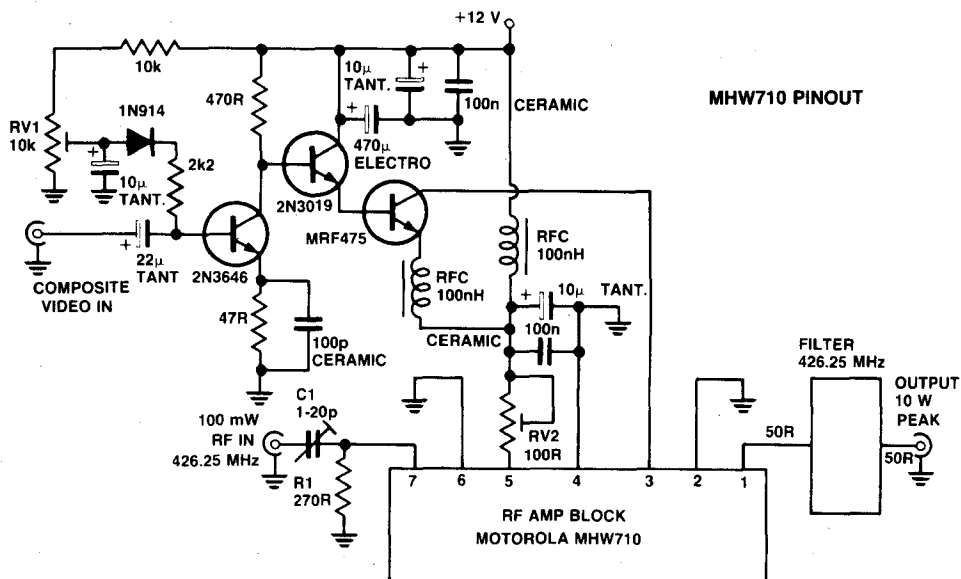
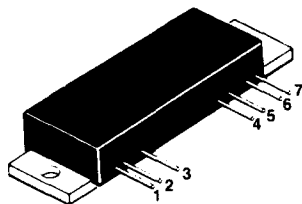
Amateur TV modulator/output stage

TYPICAL PERFORMANCE CURVES
(MHW710-2)



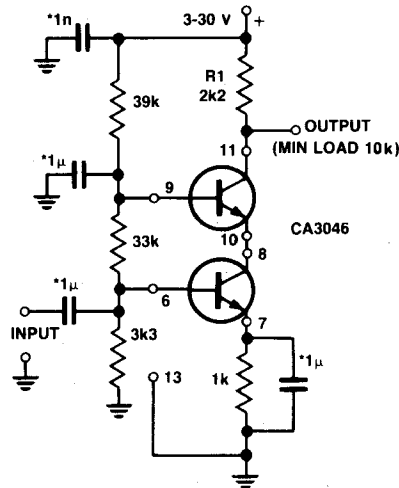
According to Les Jenkins VK3ZBJ, high level modulation for amateur TV applications has distinct advantages over low level modulation followed by a string of linear amplifiers. The main problem with the latter approach is getting the linearity, particularly with solidstate stages. This circuit (from Les) does the job, only requiring about 100 mW of RF drive at 426.25 MHz and standard level composite video input from the camera. Peak RF output is 10 watts which will put quite a respectable signal on the air.

The Motorola MHW710 UHF 'gain block' is readily available and comparatively cheap. Good UHF construction practices should be used. The MHW710 is made for stripline termination to the pins. It should be bolted directly to a heatsink with double-sided pc board (glass fibre or teflon-glass) butted beneath the pins with appropriate tracks to provide termination. C1 and R1 should have virtually no leads. The output filter need not be anything fancy, a stripline or coaxial bandpass type should do the job. Remember, you're dealing with video bandwidths, keep it broad.



Wideband cascade amplifier

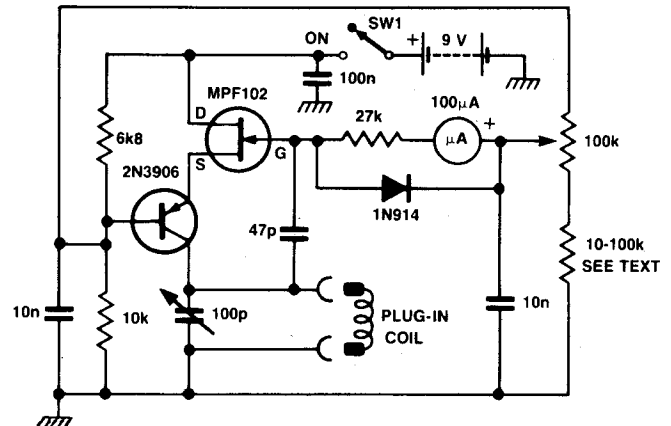
The major feature of the cascade amplifier configuration is the isolation between input and output. This makes for very good stability regardless of the load reactance. The 'lower' transistor is connected as a common emitter amplifier, the 'upper' one operating in grounded base. This circuit employs two transistors as a common substrate from a transistor array IC (CA3046), each having h_{FE} of 110 and f_T of 450 MHz. Upper cutoff determined is by R1. Increase all capacitor values to reduce lower cutoffs. A CA3018 may be used or discrete transistors such as 2N706, 2N2369, 2N3607, MPS3646 or 2N5769.



MIDBAND GAIN (LOADED) APPROX. 32 dB.
BANDWIDTH (−3 dB) APPROX. 5 kHz–4 MHz.
ALWAYS GROUND PIN 13 OF CA3046
* 50 V METALLISED POLY TYPES
OR TAG TANTALUMS (WATCH POLARITY)

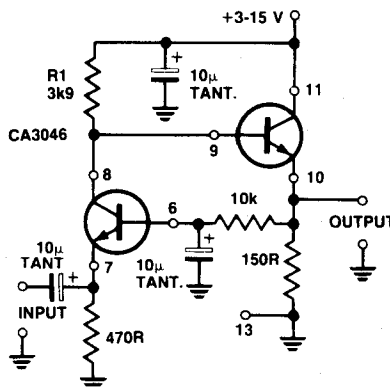
Solid-state dipper

This circuit employs a grounded-base oscillator to provide tuning via a single-gang variable capacitor where the rotor plates can be grounded. Simple two-terminal plug-in coils can be used too. The circuit will oscillate over quite a wide frequency range. The 100k pot adjusts the oscillation amplitude to suit the meter and battery voltage. The series resistor to common should be adjusted to cut-and-try so that the pot operates over its range. At upper VHF, the 47pF capacitor should be reduced. All capacitors should be ceramic types and short leads are recommended in construction.



Common base common collector wideband amp

This amplifier configuration has the advantage of low input and low output impedances — around 100 Ohms here. Two devices from a transistor array IC are used. Use dipped tantalum capacitors and keep leads short for best results. You can match the input impedance to the impedance of the source by varying R1, which varies the emitter current of the common base stage and hence the input impedance. Linearity of this configuration is very good, but gain is not high.



MIDBAND GAIN APPROX. 17 dB.
BANDWIDTH (−3 dB) APPROX. 150 Hz – 3.5 MHz.
MAX. INPUT AT 5 V SUPPLY APPROX. 40 mV RMS
ALWAYS GROUND PIN 13 OF CA3046

Tone operated switch

This is a new approach to the idea of operating a switch by means of a tone, such as a whistled note. It avoids the problems of acceptor filters formed by twin-T networks in the feedback paths of op-amps. They either oscillate or fail to discriminate against loud noises pitched just outside the acceptor frequency.

Gate IC3a squares up the input waveform and triggers IC1a and IC1b on the rising edge of its pulse. IC1a produces a short pulse (approximately 20 μ s) which is applied to gate IC3b.

IC1b is set to a time delay that equals the period of the accepted frequency. It forms a reference which measures the period of every cycle of the incoming signal.

IC2a is triggered on its negative edge by the output pulse of IC1b. At the desired frequency the pulse from IC2a (which is short — about 20 μ s) will appear at the gate almost simultaneously with the pulse from IC1a. These two pulses overlap, causing an output pulse at the gate.

The output pulses appear at intervals of T (period of the acceptor frequency) and since IC2b is timed longer than T, it is repeatedly retriggered and its output remains high for the duration of the signal.

(Note diagrams of waveforms)

When the incoming signal is too low in frequency, pulses do not coincide at gate IC3b.

When the incoming signal is too high in frequency, IC1b is prematurely retriggered, remaining permanently high at pin 10 (Q), causing elimination of any pulse output from IC2a.

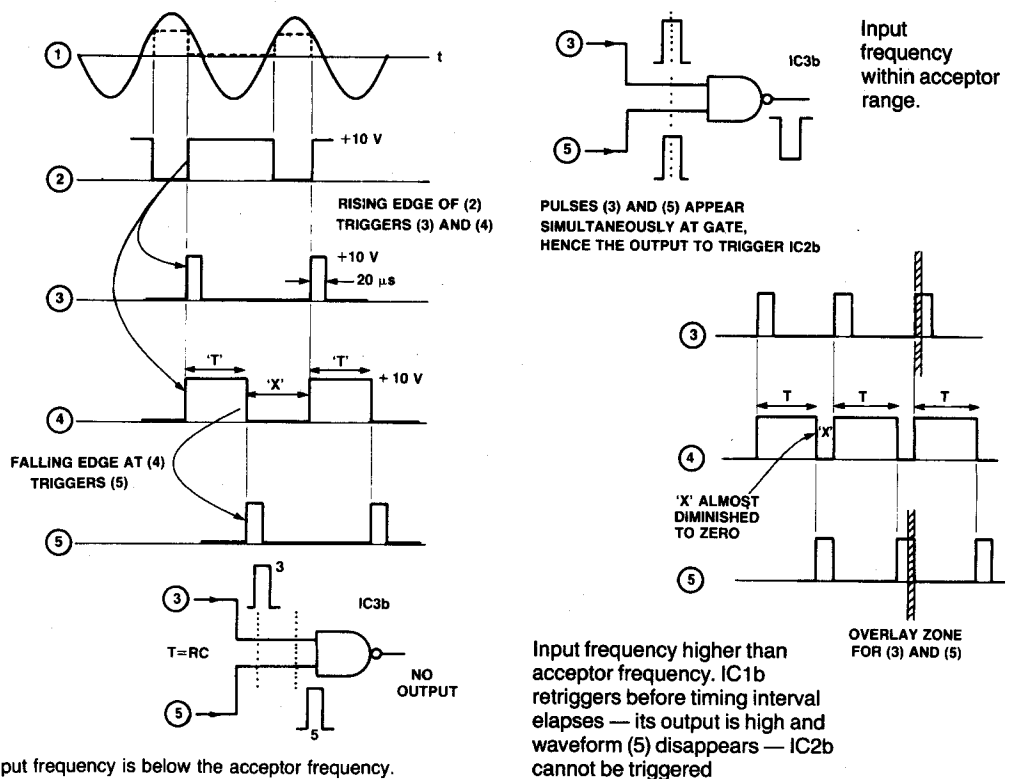
(1) Ideally, C in IC1a and IC1b should be the same value to equalise start up delay upon triggering, but with small values of C this delay is negligible.

(2) Frequency of acceptance is controlled by R and C on IC1b. Bandwidth of acceptance is controlled by R and C on IC2a.

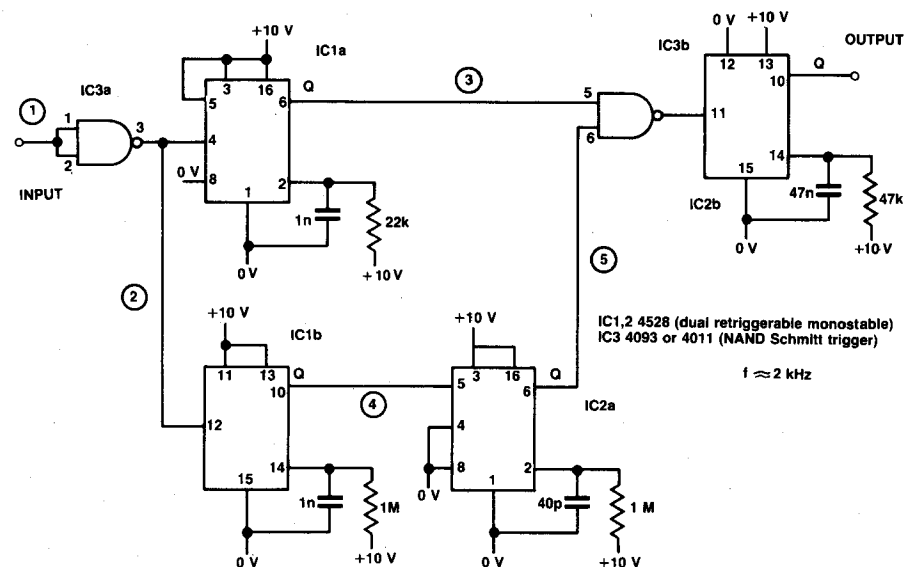
(3) A 4011 can be used in place of the 4093 for IC3, but the latter is probably preferable.

(4) ICs 1 and 2 are 4528 dual retriggerable monostables.

(5) IC2b can be connected to



Input frequency is below the acceptor frequency.



Audio frequency switch. Sine wave input (peak value equal to supply voltage) applied to input will cause output to go high within a narrow frequency range only.

be positive or negative edge-triggered; it does not matter which. IC2a, however, must be negative-edge triggered.

(6) The input signal should rise to a peak which is about equal to the supply voltage to ensure reliable triggering.

(7) The circuit will not trigger at one half or one quarter of the acceptor frequency.

I intend to use the circuit in a

'hands-free' whistle-switched intercom in my workshop (where I frequently have dirty hands).

In a breadboard assembly using two complete circuits, the values of C and R must be chosen for IC1b: low note — 1n, 1M5; high note — 1n, 1M. Cheap greencap capacitors were used. The frequencies of acceptance measured were

900 Hz and 2 kHz respectively.

This arrangement can be made to switch on to a few whistled bars of 'I did it my way', and switch off to a few bars of 'Colonel Bogie'. Needless to say, the circuit will also find use in less frivolous applications.

When a sine wave (peak value equal to supply voltage) is applied to the input and output

Wide range touch switch

Most capacitive touch switch circuits use a comparator, where the reference input must be trimmed, and retrimmed if the supply voltage is changed.

I wanted to avoid this as I wished to use the switches in a logic designer, with the supply variable over the CMOS range.

The resulting circuit needs no adjustment and operates happily over the range 4-18 V (the lower limit of the op amp to the upper limit of the Schmitt trigger).

The output of the Schmitt trigger astable IC1, R1 and C1, is fed to the capacitive divider C2 C3, rectified and then sent to

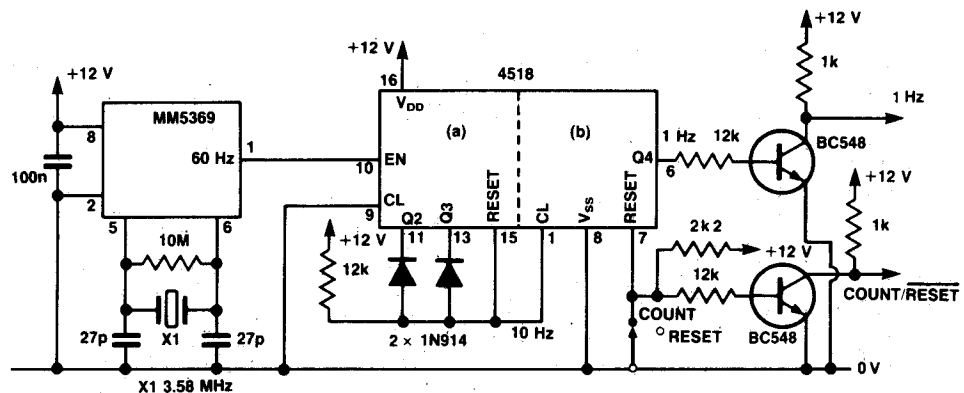
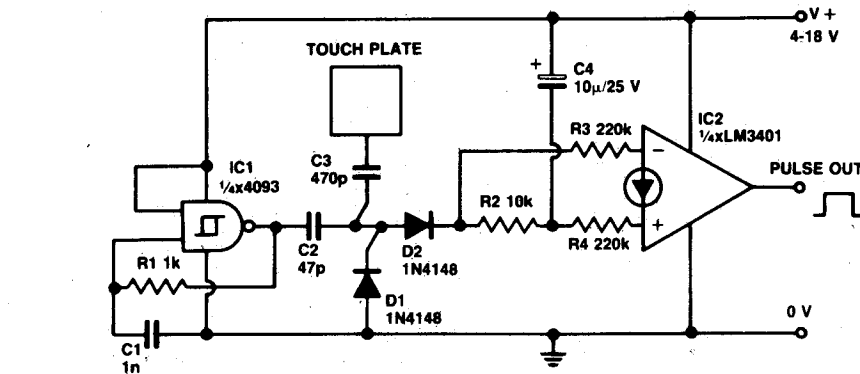
both inputs of the Norton op amp comparator. The capacitive divider principle is well known and previously published. However, the way it is employed in this circuit is my own idea.

R2 biases the non-inverting input just below the inverting input, thus the output is normally low. When the plate is touched, the resulting drop in voltage is sent to both inputs, but in the case of the non-inverting input it is delayed by R2 C4. Thus the inverting input momentarily goes below the non-inverting input, turning the op amp on for that time and

producing a short positive pulse at the output.

The op amp swings over virtually the entire supply range, resulting in a reasonably clean pulse with no switch bounce. This pulse may be used as a trigger for a monostable; or sent to a Schmitt trigger for squaring up; or sent to an op amp or JK flip-flop toggling circuit; or any other controlling function.

A LM3900 can be used instead of the LM3401. As both the op amp and the Schmitt trigger come in quad packages, the circuit is ideal for banks of four switches.



1 Hz clock generator

Geoff Nicholls, ETI project engineer, designed this circuit which has been used with a Microbee to get lap times at sporting events.

The 1 Hz and COUNT/RESET signals were connected to CLK and CTS of the serial port, and the port supplied the

+12 V to the circuit.

I initially wrote the timing program in BASIC, which was able to poll the serial port fast enough to work alright. However, the latest program is in machine code and takes advantage of the Z80 PIO's control mode interrupt feature.

The COUNT/RESET switch resets the last decade divider, so the overall timing is accurate to within 0.1 second of switching to COUNT. The other half of the dual decade divider is set up to divide by six by resetting the counter to zero when Q2 and Q3 are high.

will go high within a certain narrow range of frequencies. Outside this range the response will be zero.

The frequency at which the circuit responds is a function of the time constant set by the capacitor and resistor on IC1b. The 'breadth' of the response range depends on the time constant set by the capacitor and resistor on IC2a.

Low cost appliance-timer

I originally designed this timer for controlling irrigation systems, particularly systems where frequent short duration applications are required. It proved very cheap, easy to make and reliable. Subsequently it has proven equally valuable for longer period timing applications, turning lights on and off each day, turning open field irrigation systems on and off twice a week and so on. In short, this timer will lend itself to any application where cheap reliable control is required.

The basis of the timer is Exars' 2240 programmable timer/counter. This is actually a 555 with its output wired to a binary counter. Eight outputs are available and they change state in the normal binary fashion on every pulse from the 555. The timing period of the 555 is set by an RC network on pin 13 of the XR 2240.

The counter is arranged in a 'wire-or' configuration through the DIL switch. When the counter outputs match the switch outputs the output pin of the 2204, pin 10, goes high and counting is inhibited until the next trigger pulse.

The timer uses two of these counters, one to measure interval and the other duration. To initiate circuit action, SW3, the start button, is depressed. This puts a negative going pulse onto pin 11 of IC2. The rising edge of this triggers the IC. Pin 10 goes low and switches off Q2. This drives the collector up almost to the supply rail, turning on Q3, and thus the relay. It also acts as a positive going voltage on pin 11 of IC1, and so triggers it. The circuit operation of IC1 is now identical to IC2. The positive going voltage on pin 11 initiates the count sequence, pin 10 goes low, turning off Q1 and turning LED2 on. Incidentally this also puts a low voltage back onto pin 11 of IC2, thus effectively resetting its trigger circuits.

The result of this is that both counters are counting at the same time. However, they are not counting at the same rate. IC2 (the duration timer) reaches its turn off count long

before the interval timer (IC1). When this happens pin 10 of IC2 goes high and so turns the relay off.

The circuit will now wait for IC1 to finish counting. This defines the 'interval'. When it is finished pin 10 rises rapidly, becoming a rapid positive going voltage for pin 11 of IC2, and it thus has exactly the same effect as the original start pulse. The whole sequence repeats itself again.

The duration of the two timers is set by a combination of the timing period defined by the RC network on pin 13 and the setting of the DIL switches. $T=RC$ subject to the limitation that R should be between 1k and 1M and C between 7n and 1000 μ . Pin 1 will, in fact, change states at this rate, pin 2 at twice the duration and so on. With eight outputs it is possible to derive accurate timing intervals 255 times longer than RC. This gives an approximate timing limit of about 70 hours.

Construction is quite straightforward, paying attention to polarity of diodes and capacitors. Make sure that the choice of filter capacitor is rated above the rectified voltage, i.e.: >12 V for 240 V switching circuit and >32 V for 24 V switching circuit. The manual override switch must

be a DPDT with adequate current capability and standard size (not mini) to enable sufficient separation between leads when soldered. Be sure to connect the output leads to the poles, with both mains leads at one throw and both relay leads at the other. This setup provides isolation between the two streams, but it is still necessary to pair the active and neutral leads on each pole to reduce the risk of short circuit and to comply with the standard wiring convention.

The choice of relay, manual override switch, fuse and wire gauge is decided by the output requirement. Usually 5 A at 240 V is adequate for your own use, but 10 A is safer if the unit is installed elsewhere. For irrigation control, a 1 A fuse on the 24 V line allows an adequate margin for circuit and solenoid operation.

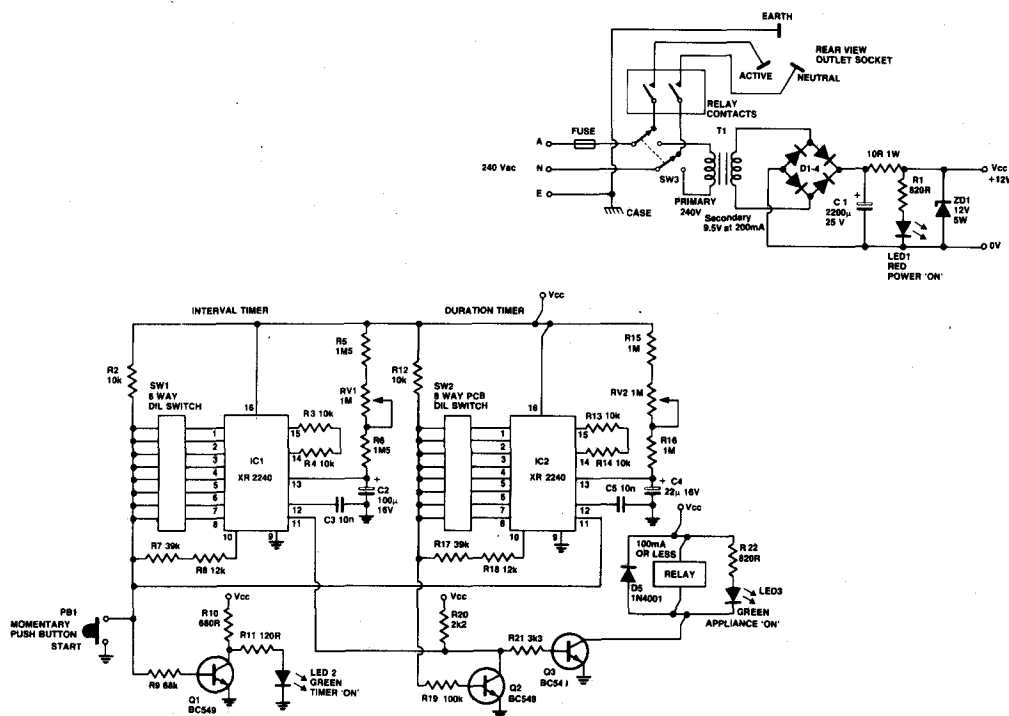
I generally use a 185x70x160 mm metal cabinet (such as sold by Dick Smith) for housing the unit as it provides a good amount of room inside for isolating the mains and transformer and can be directly earthed. For external applications, the timer can be housed in a rigid PVC junction box, with supply and output run through conduit, transformer and PCB fastened with nylon bolts and all holes sealed

with silicone.

Once construction is completed, confirm the 12 V supply. Then turn on switch 1 of each DIL switch, grab a stopwatch or watch with seconds clearly displayed and power on. The red LED only should be on. If one of the timers has accidentally fired (either green LED is on) turn the power off and on again. When ready, depress the 'start' button and start timing immediately that you release it. Timing extends until the moment that the 'appliance on' LED cuts out. Adjust RV2 and repeat until the required duration is obtained.

Repeat the above for the interval period, adjusting via RV1 and timing from when you release the start button until the 'appliance on' LED lights for the second time. Having completed this, bundle up your timer.

If the timer is being dedicated to one purpose with constant interval and duration periods, you can streamline the project (and the cost) by hardwiring the timer output connections, deleting the manual override, mounting the fuse in a PCB holder and connecting the appliance leads directly to the relay, bringing the all-up cost of components down below \$30 for 240 V at 5 A.



Frequency-operated switch

This circuit was designed by A. Macdonald of Croydon Victoria. It will turn on a relay (or a triac, SCR etc) when a given input frequency is reached.

Using the components shown in the circuit, the switching frequency is 480-500 Hz where

$$f_{\text{switching}} = \frac{1.27}{V_{CC} \times R_1 \times C_1}$$

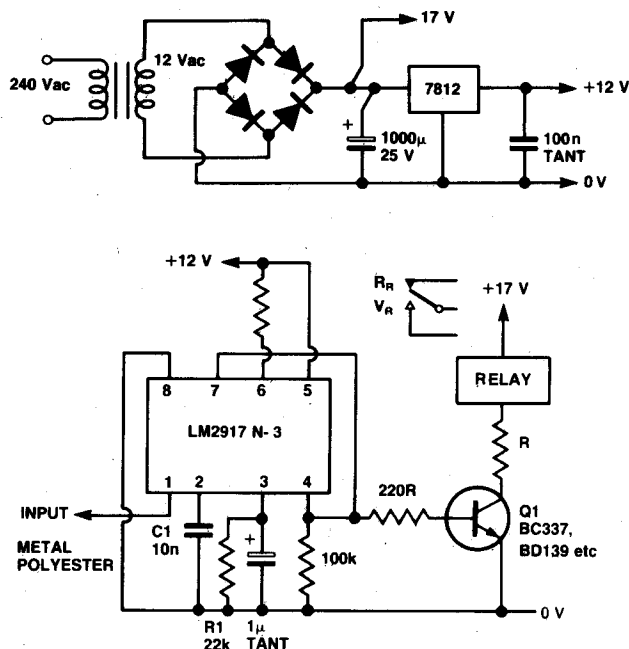
The IC can interface directly with proximity switches and can be used for overspeed pro-

tection of any rotation device. The input may be either a sine, square or triangle wave.

The circuit uses the LM2917 frequency/voltage converter in a switch mode so that when the input frequency exceeds a specified amount, its output will go high. This causes the transistor to switch on, turning on the relay and switching the contacts.

The 22k resistor R1 may be varied to change the frequency at which the device switches.

$$R = \frac{17 - V_{\text{RELAY}}}{V_{\text{RELAY}}} R_{\text{RELAY}} = \left[\frac{17}{V_{\text{RELAY}}} - 1 \right] R_{\text{RELAY}}$$

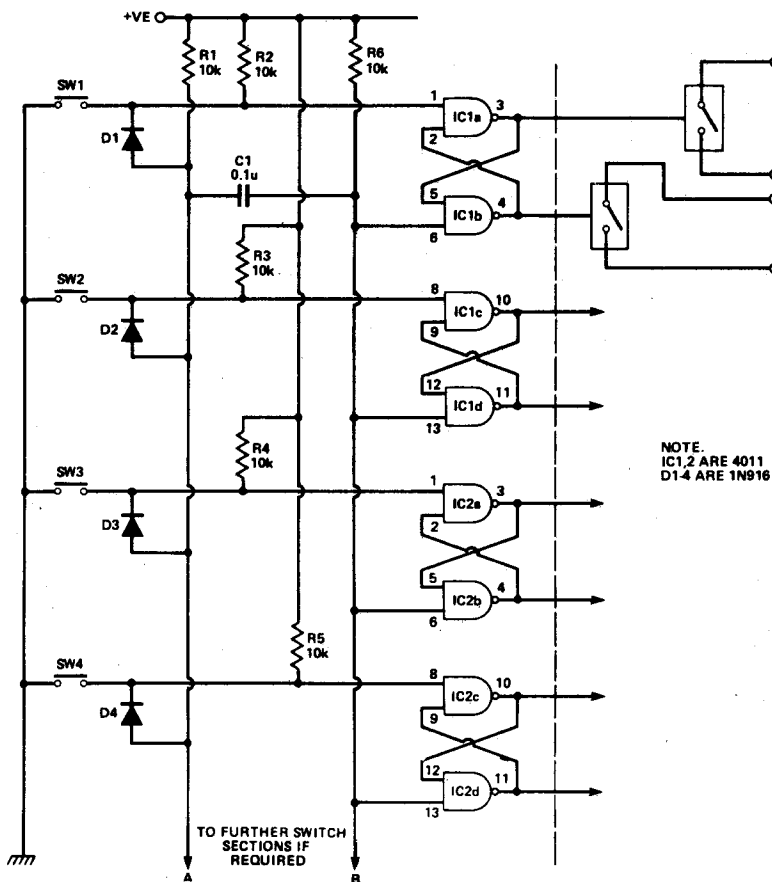


Latching switches

This circuit allows individual, momentary-action, push to make switches to be used in a ganged, latching mode for logic or low level audio signals.

When a switch is pressed the common reset line of all the latches sees a momentary ground, through C1 and its associated diode, this resets the previous selection and allows the selected output to latch.

A number of different devices could be connected to the latch outputs to provide various types of switches, bi-lateral switches are shown on the circuit. Further stages can be added to the bank as required, by connecting to points A and B.



UJT timer

A unijunction transistor can be employed to make a simple timer for periods up to a few minutes. The time delay you get with this sort of circuit is:

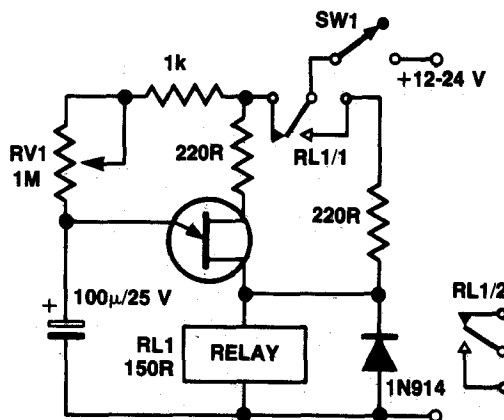
$$C3 = C/Ao$$

$$R1 = Ao/Q.2.\pi.f.C(2.Ao + 1)$$

(Ao is the gain of the high-pass filter; $\pi = 3.1416$).

The time constant of $R3.C4$ must be greater than five times the period of variation of the input signal.

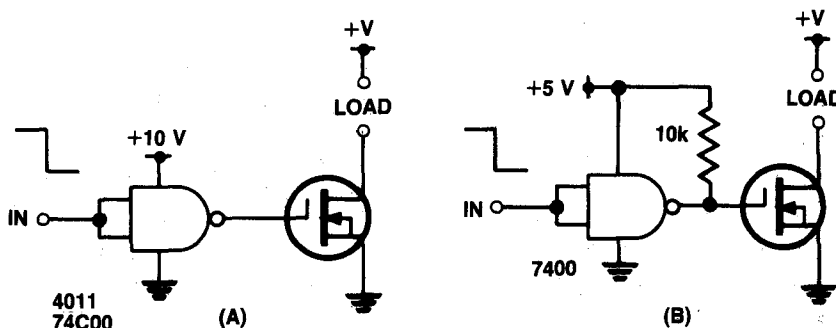
Now determine the gain of the output stage. You can make this part of the audio preamp drive the output stage and give it quite some gain. Or, if you are adding on this squelch to an existing circuit, op-amp 2 might simply be a buffer with a gain of one. Its gain is simply $R5/R4$.



UJT: 2N2646 OR SIMILAR

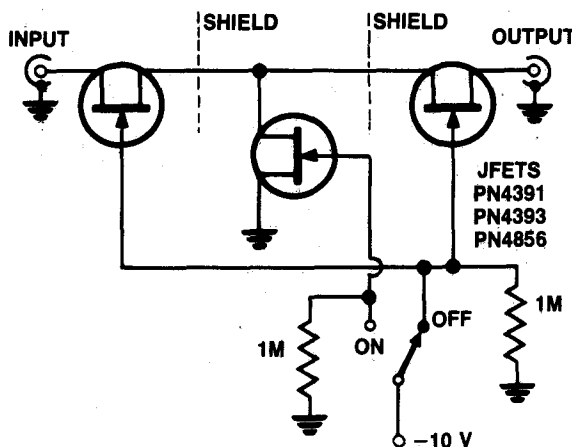
Driving VMOS switches

VMOS devices make excellent switches as they can handle high voltages and/or large currents. Some special types are made just for this application. However, if you need to drive them from TTL or CMOS, then the drive requirements differ. These two circuits show the different ways.

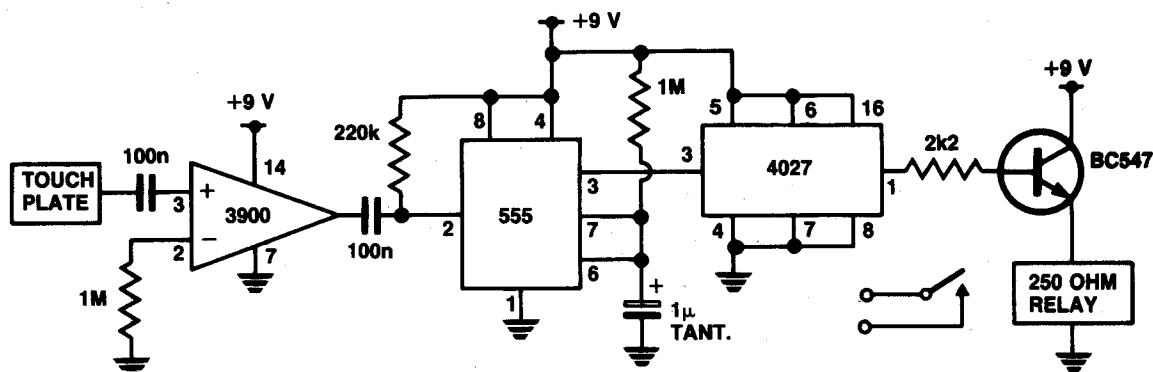


Video switch

A JFET with a low on resistance and a high off resistance (and low capacitance) makes a good wideband electronic switch. With decent RF construction (short leads, proper shielding), this switch can provide an off attenuation greater than 80 dB and insertion loss of 6 dB, sometimes less.



Touch-on, touch-off switch



This circuit can be used to switch a lamp on and off, an electronic motor, a radio or other electrically operated device.

The 3900 op-amp (only one from the quad package) amplifies stray hum fields picked up on the body, triggering a 555, the output of which drives a 4027. The output of this latches high and the transistor

operates the relay, the contacts switching the load.

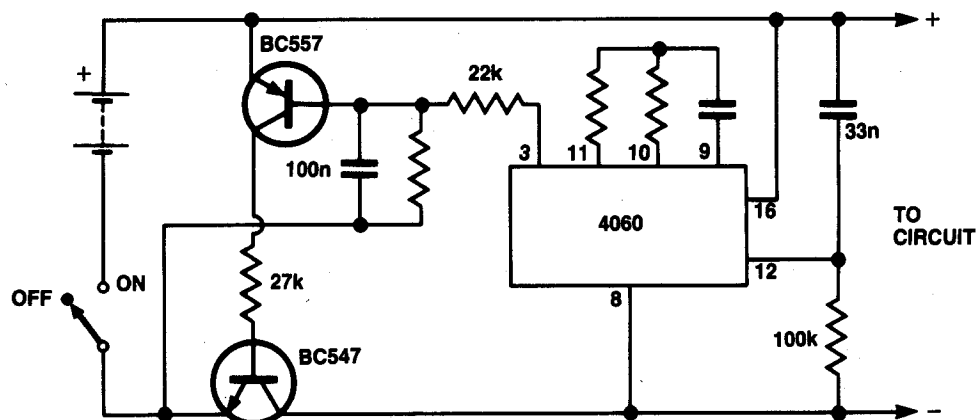
Supply voltage is relatively non-critical; five to 12 volts is OK. Make sure the voltage rating of the relay coil matches the power supply voltage though.

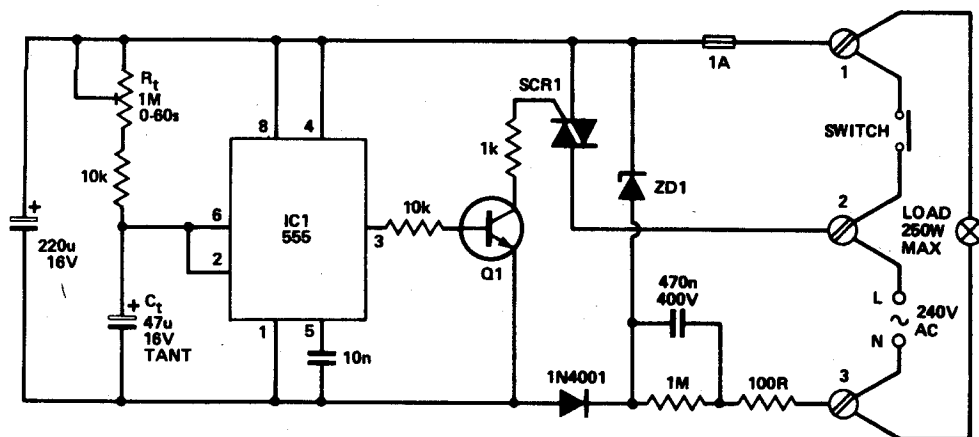
The circuit may be sensitive to thunderstorms — keep the touch-plate area small.

Battery saver

This circuit automatically cuts off the supply from battery-operated equipment should it be accidentally left on.

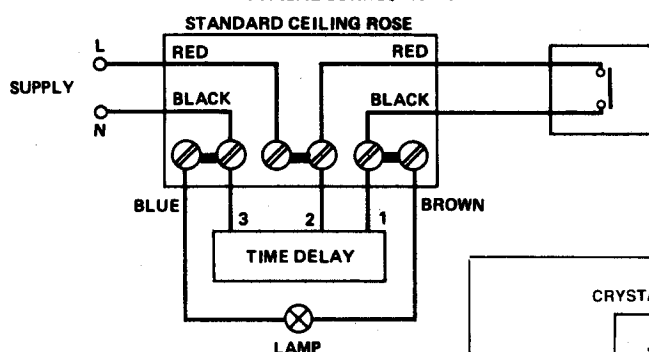
The 4060 is an oscillator and counter, determining how long the power is supplied. The values shown provide an oscillator around 30 Hz and the counter provides a division ratio of 16 384, resulting in a delay of around nine minutes. The last stage output of the 4060 (pin 3) goes high at the end of the count, turning off the BC557 and BC547. Only a tiny current is then drawn from the battery, via the 10M resistor. To reset the circuit once it has timed-out, simply turn off the switch and turn it on again. This could actually be a push-button.





NOTE:
IC1 IS 555
PIN 7 IS NOT CONNECTED
Q1 IS BC337, ZTX300 ETC.
SCR1 IS TIC 208
ZD1 IS 12V ZENER

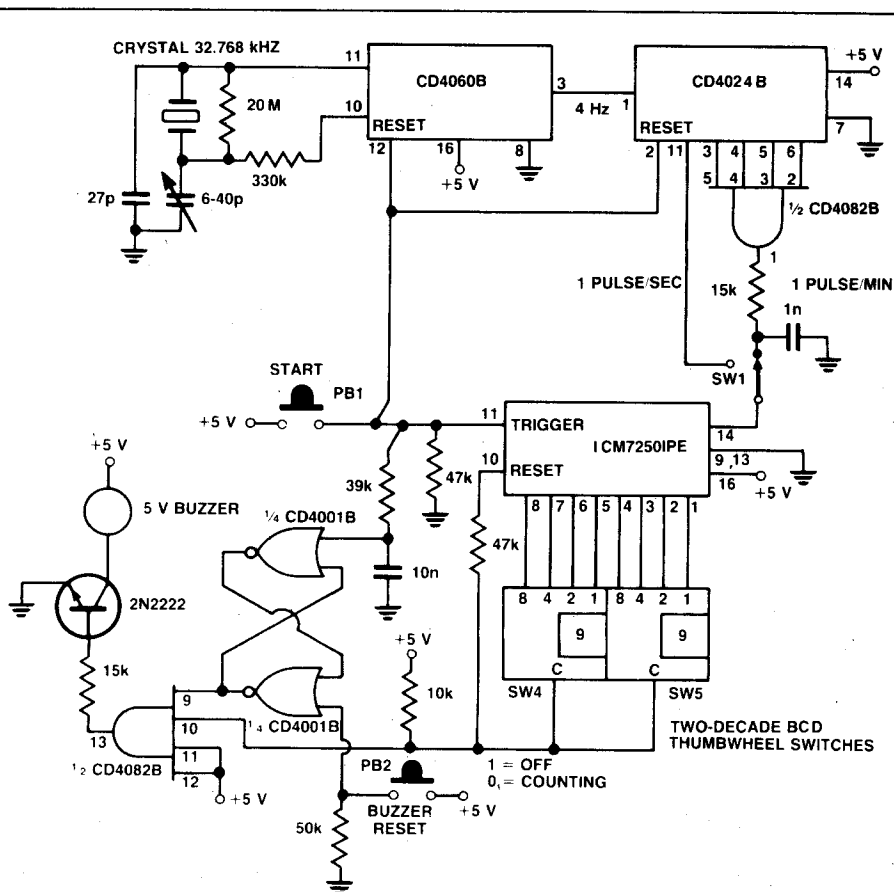
TYPICAL CONNECTION SCHEME



Mains time delay switch

Ideal for a corridor light timer. The switch is a main-rated momentary action pushbutton. When it's pressed, the timer will operate for a time equal to $1.1 R_t C_t$. At the end of this period, both the load and the circuit are disconnected.

Programmable 0-99 seconds/minute timer



This precision programmable timer can be set to time elapsed intervals up to 99 seconds in one second increments or 99 minutes in one minute increments, using two BCD thumbwheel switches. The timebase is selected with SW1 (seconds or minutes). The period is selected with the thumbwheel switches. This sets the 7250 programmable counter. The start pushbutton, PB1, resets the oscillator and counters and counting begins. The 7250 counts until the pre-programmed value is reached, at which time it resets, pin 10 of the 4082 is enabled and the buzzer sounds. Pressing PB2 turns it off.

Analogue frequency meter

H. Nacinovich of Gulgong NSW says that this circuit is simple, easy to build and get going, and uses very little standby power.

There is no reason why it could not run off a 9 V radio battery but some form of power supply voltage regulation is recommended.

The circuit might be built into a suitable case, complete with a meter, or it could be used as an outboard adaptor (i.e. minus meter movement) which can be plugged into an ordinary multimeter.

Alternatively, although I have not tried this, it could be built into an existing multimeter case. For example, if a spare multimeter is on hand one might be willing to sacrifice, say, the 'Ohms' ranges and convert the associated switch positions to 'Frequency' ranges. The modification should not be beyond the ingenuity of most hobbyists.

Another possibility is to incorporate it into an audio signal generator.

I must confess that the circuit does not involve any new ideas. However, I have not seen any analogue frequency meter projects published recently. So, I thought that this project might be appreciated, if not by the advanced enthusiast, then at least by the newcomer or one with limited cash and limited spare time.

There have been plenty of digital frequency meter circuits published recently. Bearing in mind the performance capability of such circuits and the relatively low cost of digital ICs these days, the popularity of DMFs is not surprising. Even so, I would not consider a DFM either a simple or a cheap project to build.

Despite all the obvious advantages of a DFM there are many situations in which one might get by quite happily with an analogue meter which covers the audio to sub-radio spectrum and has about the same order of

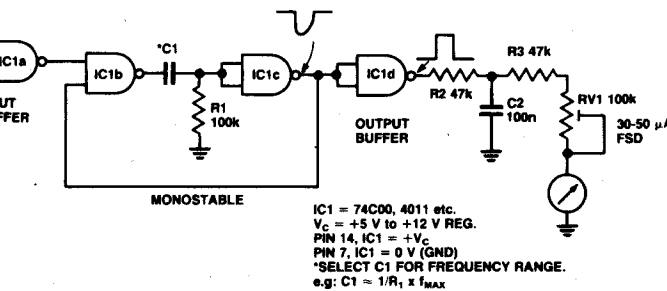


Figure 1. Simple monostable configuration.

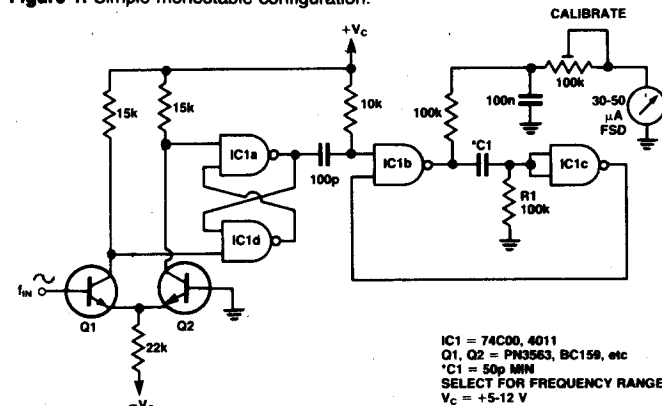


Figure 2. Modified frequency meter.

R1	C1	Theoretical max. frequency of measurement	Recomm. calibration FSD
100k	100n	143 Hz	100 Hz
100k	10n	1.43 kHz	1 kHz
100k	1n	14.3 kHz	10 kHz
100k	100p	143 kHz	100 kHz

accuracy as, say, an ordinary multimeter. Now, if such a device could be built using a single, low cost IC, a few passive components, a simple power supply and, possibly, a meter which is already on the workbench or lying idle in a cupboard somewhere, well...

The circuit described has the best balance of the desired features. I incorporated it into a Wien bridge-type audio oscillator which I had previously built and used the meter to monitor the output frequency.

The obvious advantage of this arrangement is that I need not rely on the dial calibration which is subject to too many sources of error. From tests I have made to date, the linearity and stability which can be obtained with the circuit are surprisingly good over the entire range of my oscillator, 20 Hz to 200 kHz.

The circuit shown in Figure 1 is based on the use of CMOS NAND gates in a simple monostable configuration. It

produces an output current signal which is linearly proportional to the input frequency.

Two gates, IC1b and IC1c of a quad package form the heart of the monostable. IC1a and IC1d are employed as input and output buffers respectively. Their purpose is mainly to square up any rounded corners on the input and output signals.

The output from IC1d is in the form of a series of positive rectangular pulses of constant width (determined by the time constant $R1C1$) and a frequency equal to the input frequency. These pulses are integrated and the resultant signal is applied to a meter movement of suitable sensitivity.

I used an ordinary multimeter movement with 30 µA FSD sensitivity but there seems to be no reason why a less sensitive movement (e.g. 1 mA FSD) could not be used provided that the values of $R2$, $R3$ and $VR1$ are adjusted accordingly.

Calibration will depend on the choice of component values, the meter sensitivity and on variations between ICs from different manufacturers. Thus some experimentation with component values may be necessary and the values shown are therefore meant as a guide only.

With any combination of $R1$ and $C1$, the upper limit of frequency which can be measured will depend on the product $R1C1$. As a rough rule of thumb choose $R1C1$ to be equal to $1/f_{max}$, where f_{max} corresponds to the chosen input frequency for full scale deflection.

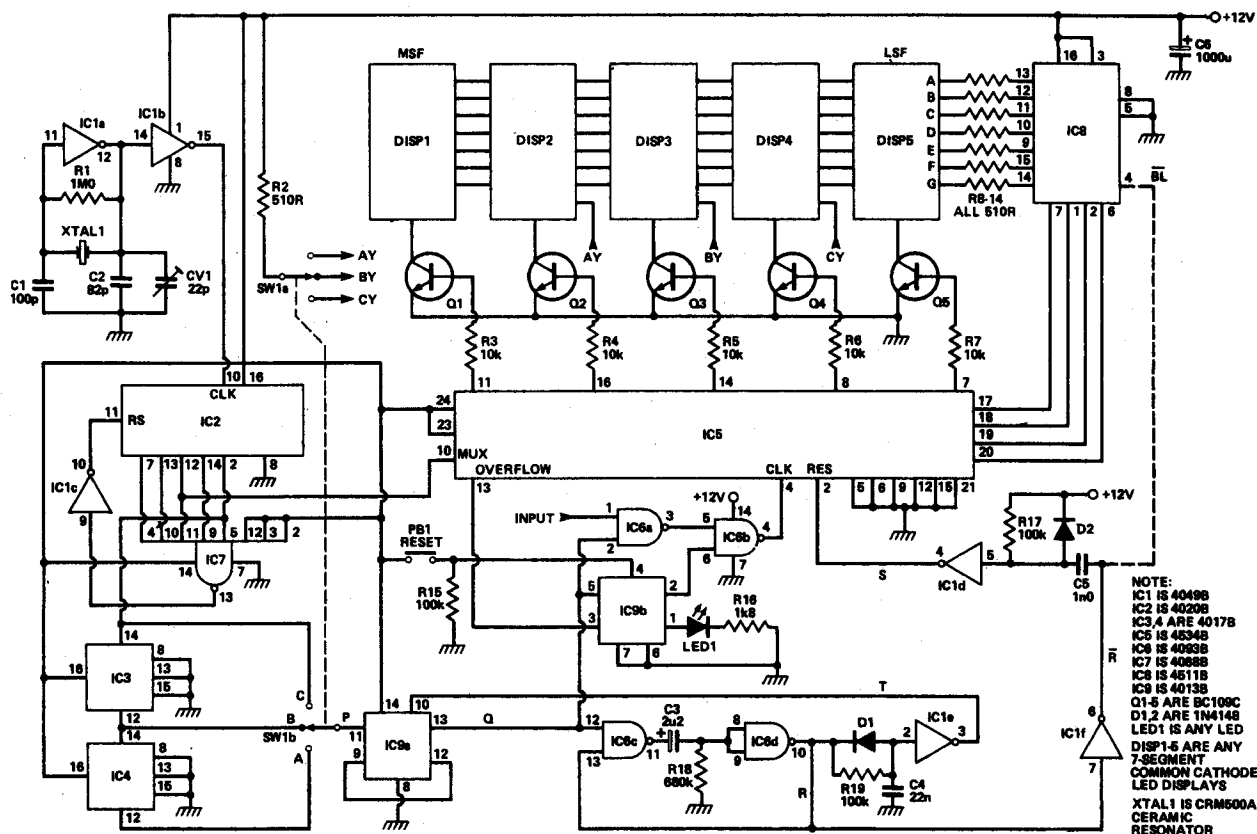
Then, with an input signal of known frequency adjust $VR1$ for a suitable meter deflection. It is possible to cover different frequency ranges simply by switching in different values for $C1$, leaving all other component values as they are. For example, to increase the range by 10, reduce the value of $C1$ by 10, and vice versa. Some trimming of component values may be necessary.

Calibration will also depend on the supply voltage which should be regulated. I have used a 12 V mains powered regulated supply, but if a 9 V battery is used I would recommend the use of a series regulator with low standby current, such as the $\mu A105$.

Figure 2 is a modified version of Figure 1 and it gives a very good performance. It is useful when the input signal needs to be conditioned, such as low level sine waves, to produce a square wave input to the monostable portion of the circuit.

Basically, IC1a and IC1d are wired as a flip-flop which changes its output state with a snap action when the inputs to these gates alternately go low. There are a number of different ways of driving such a flip-flop, but in this case I chose to use a pair of transistors connected as a differential amplifier.

This has the advantage that it can be dc coupled to low frequency, ground referenced signals and it also gives a modest amount of signal amplification. However, this arrangement does need a dual power supply. The input sensitivity is better than 200 mV p-p, depending on the gain of the transistors and the supply voltage.



Digital frequency meter

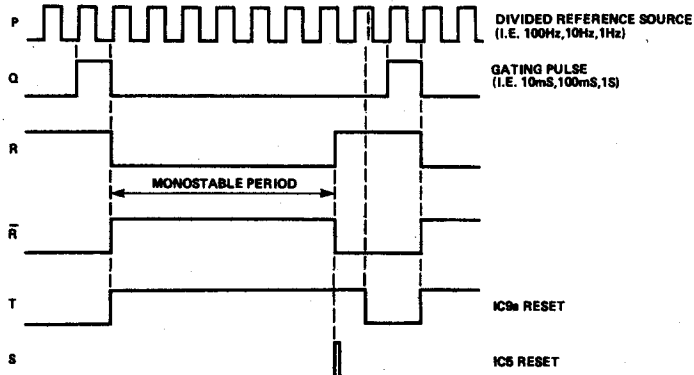
The design shown is an alternative to those projects for DFMS that utilize one of those new-fangled all-in-one DFM chips. As you can see from the circuit diagram, the only additional circuitry required is an input preamplifier and a suitable regulated 12 V power supply.

IC5 is a real-time five-decade counter incorporating a multiplexed BCD output. With the aid of IC8 (a BCD-to-seven-segment decoder) and transistors Q1-5, the counter and display section of the DFM is formed. The B L A N K pin on IC8 is used to extinguish the displays while IC5 is counting, otherwise pin 4 of IC8 should be connected to the positive rail. The frequency reference oscillator is somewhat unique in that a 500 kHz ceramic resonator is used. In practice it offers reasonable accuracy; however, the circuit can be easily modified to use a 1 MHz quartz crystal. In this case, the connections between IC2 and IC7 of the frequency divider section will require the inputs of IC7 to be connected to pins 3, 5, 12, 14 and 15 of IC2. Pin 14 of IC3 should also be connected to IC2 pin 2, and a suitable multiplexing frequency of around 1 kHz should be fed to pin 10 of IC5.

to give the reading period of the display, when triggered, by enabling IC8 and disabling IC9a. At the end of the monostable period, a short pulse is produced at S which resets the counter. IC1e is there to ensure that IC9a is not enabled before the reset pulse to the counter is produced (see T), otherwise all hell will break out!

Finally, the D-type flip-flop that remains is used as the basis of the overflow indicator; on the transition of the counter from 99999 to 00000, a pulse is produced at IC5 pin 15 which latches IC9b pin 1 high, thus lighting up the LED. Pressing PB1 resets the whole system.

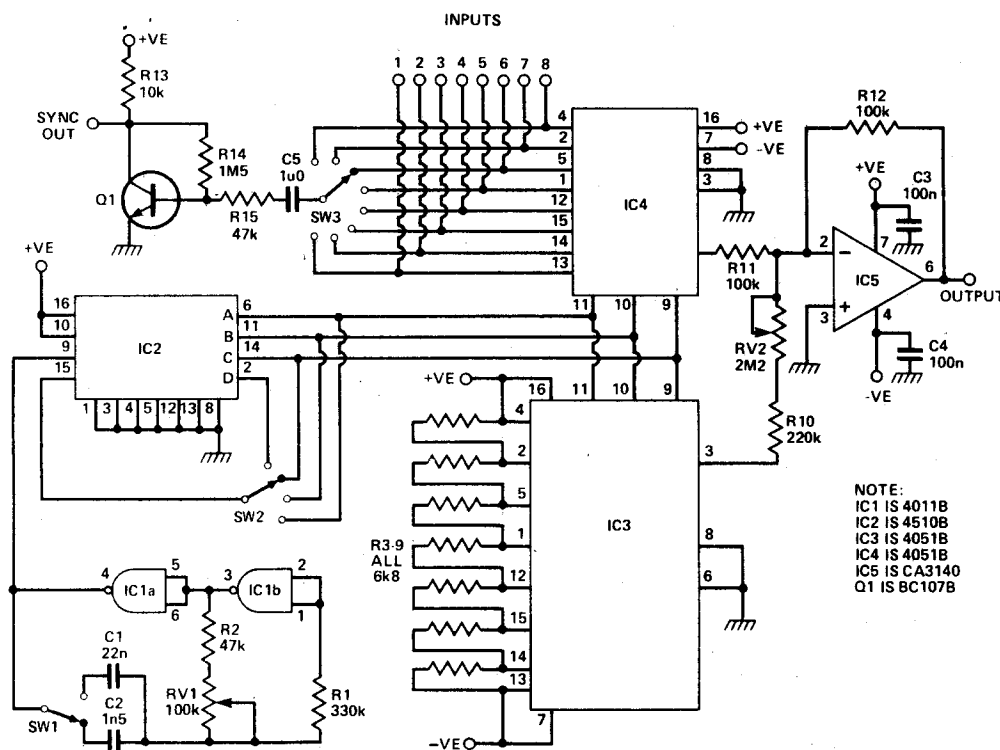
Depending on the position of SW1b, either 1Hz, 10 Hz or 100 Hz will appear at IC9 pin 11 (see Fig. 2, point P), where IC9a is a D-type flip-flop configured to divide by two. Should IC9a be continuously enabled, the output of IC9a will, in fact, be a square wave of half the applied frequency with a mark/space ratio of 1:1. This means that for a 1Hz applied frequency, 0.5 Hz will appear at IC9a pin 13 and the time for which the cycle will be high is, in fact, one second. This is then fed to the gate IC6a. However, only one such gating pulse is produced, after a certain time period set by C3 and R18. The monostable formed round IC6c,d is used



Eight traces on single trace 'scope

This simple and inexpensive circuit can display up to eight traces on a single beam oscilloscope. Even though the capacity of such a simple circuit is limited, it will be fine as part of a home workshop. The frequency response is DC to 100 kHz with the circuit shown, and the scope sensitivity should be 0V5 per division, preferably DC-coupled.

IC1 is the clock oscillator: SW1 selects chopped or alternate mode. RV1 allows the frequency to be ad-



justed over the range 10-30 kHz or 200-700 Hz depending on the setting of SW1. The counter IC2 controls the two analogue multiplexers IC3, 4. One, two, four or eight traces may be selected using SW2, which couples one of the counter outputs back to the reset pin to reset the IC after the desired count length. The analogue inputs of IC3 are connected to a voltage divider, R3-9, and the output is connected, via R10 and RV2, to the negative input of the op-amp, IC5. This allows the offset voltage of the op-amp to be adjusted over a wide

range. The trace changes position by changing the offset voltage, which has no effect on the gain of the op-amp. RV2 allows the voltage offset between the upper and lower traces to be adjusted from $\pm 0V3$ to $\pm 3V$, ie RV2 is the position control. Separate controls aren't needed here. The eight channel inputs are connected to the analogue inputs of IC4.

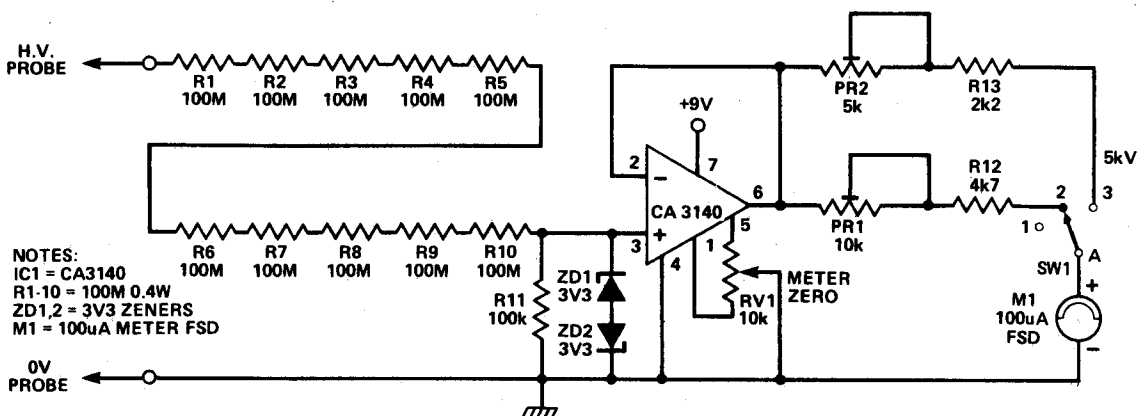
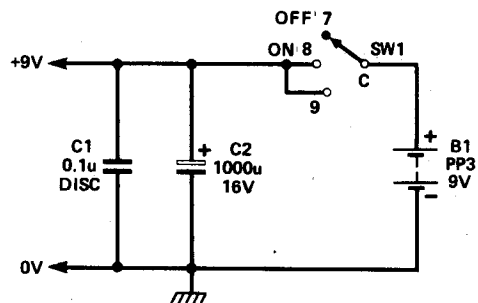
The circuitry around Q1 and SW3 is to allow external triggering of the scope. This circuit isn't strictly necessary, but will often give a better display. The whole circuit is designed

for a $\pm 6V$ power supply, and the inclusion of IC3, 4 means that $\pm 7V5$ should never be exceeded.

Why is IC5 wired in the inverting mode, when the non-inverting mode would give better results? The offset adjustment of a non-inverting low-gain amplifier using the method shown here would affect the gain. Also, the inputs should not be left open-circuit as this will cause notches on the traces. The inputs should therefore be connected to an inverting amplifier, preferably with an attenuator due to the low sensitivity.

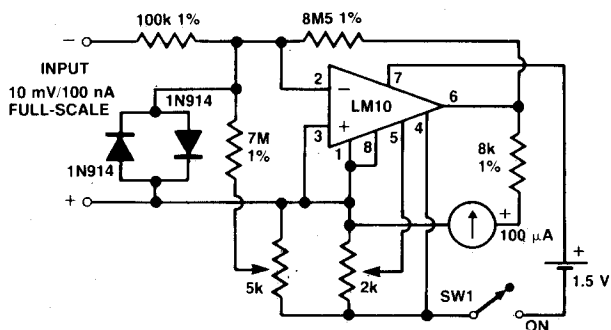
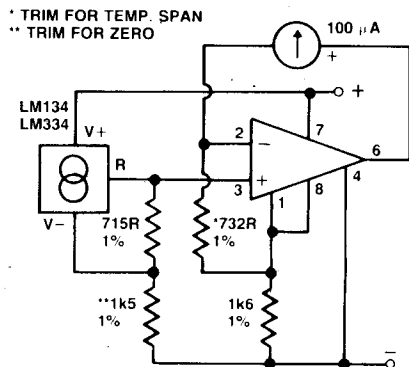
EHT meter

This simple dc meter circuit will read 0-5 kV and 0-10 kV. A high impedance input op-amp is used as a meter amplifier, driving a 100 μ A moving coil meter calibrated 0-5 and 0-10 to read kilovolts. The input divider comprises a 1000M resistor, made up of 10 x 100M resistors or a 1000M EHT probe, and a 100k resistor. These should be 5% types at least, preferably 2% types. A Class 2 or Class 2.5 (common type) meter movement should be used which will provide 2% or 2.5% full-scale accuracy. The resistive divider need not be any more accurate. The two zeners on the input provide over-voltage protection. Calibration is simple. Short the input and adjust RV1 to zero the meter. To calibrate the 10 kV range, set SW1 to 2 then apply 1.00 volts across R11 and adjust PR1 so the meter reads full scale. For 5 kV, set SW1 to 3 then apply 0.50 volts across R11 and adjust PR2 to read full scale on the meter. Resistors R1 to R10 should be mounted in a 'string' and covered in heatshrink tubing to prevent arc-over between their ends at peak voltage. Use $\frac{1}{2}$ W or 1W resistors for their voltage rating.



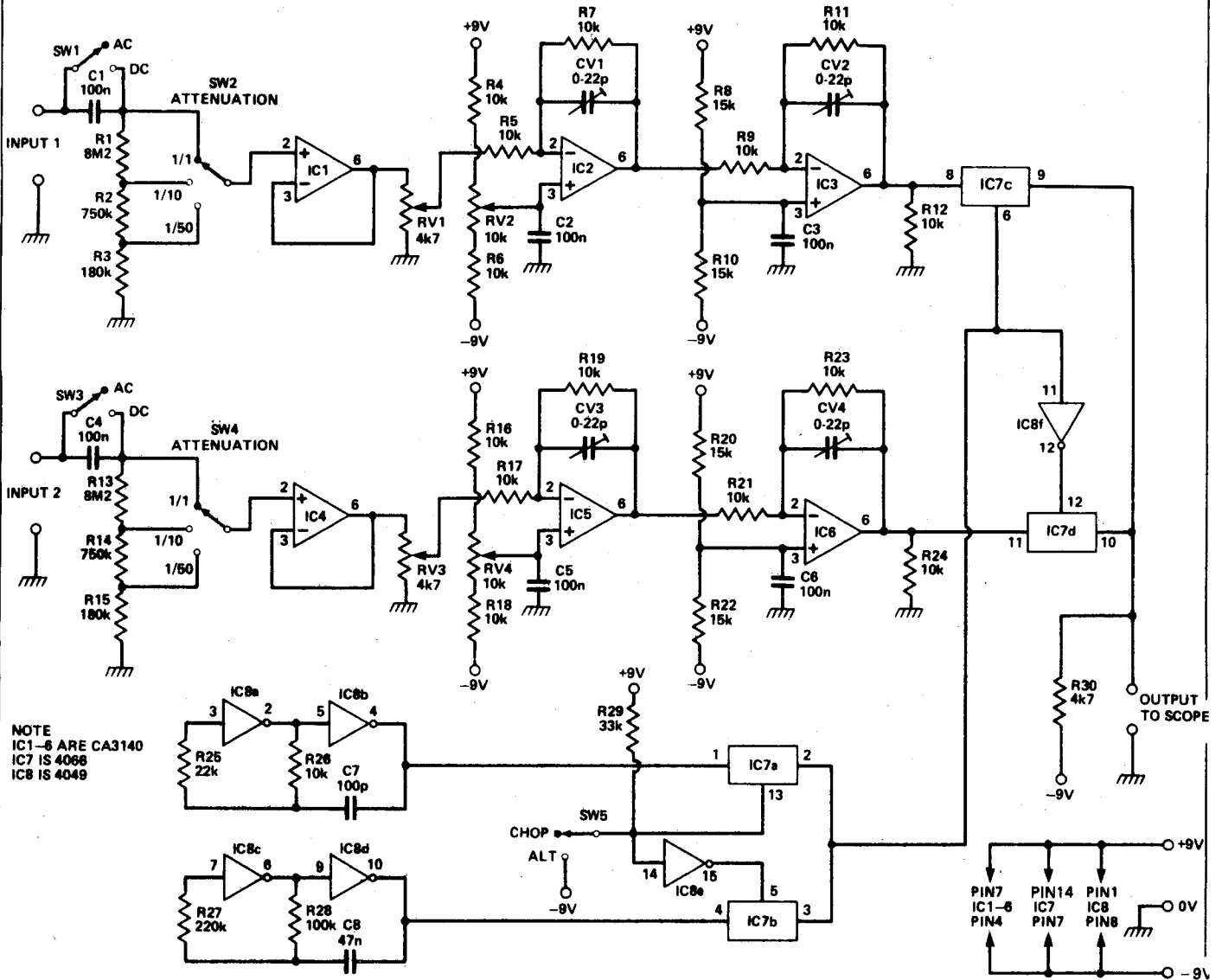
0-100°C thermometer

A precision temperature sensor, the LM134, provides an output of 10 mV/ $^{\circ}$ K. The LM10 provides 'normal' temperature offset and amplification so that a moving coil meter movement can be used to indicate temperature.



mV-nA meter amplifier

This meter amplifier can be calibrated to read either 10 mV or 100 nA full-scale. Zero set is provided by the 2k trimpot and full-scale calibration by the 5k trimpot. The back-to-back diodes on the input provide input overrange protection.



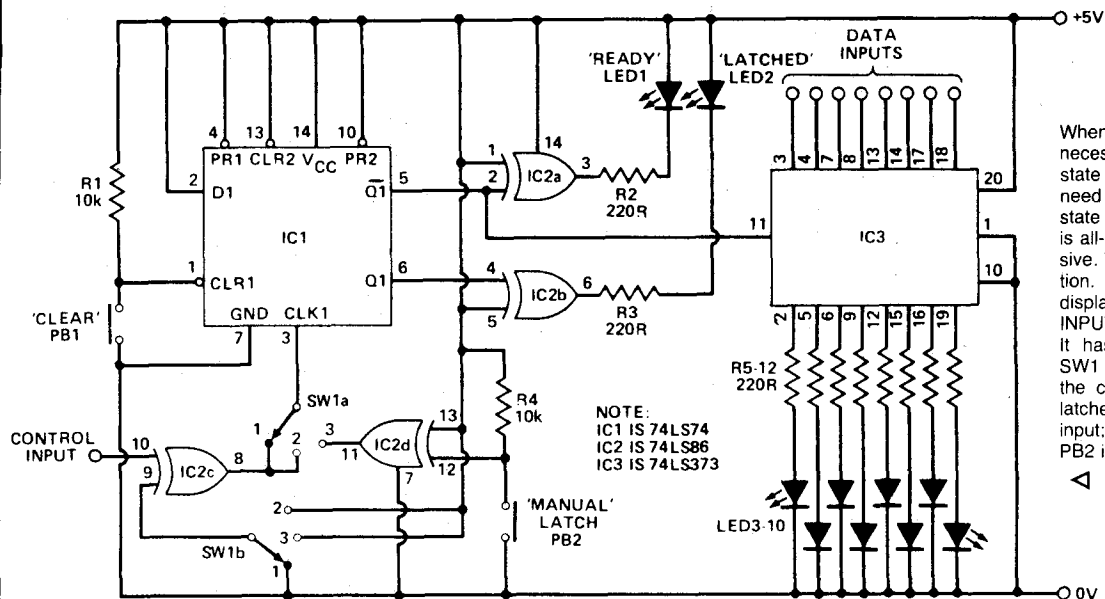
CRO dual-trace switch

This permits a single-channel CRO to be turned into a dual-trace unit. Two modes of display are provided: 'chop' and 'alternate'. When examining frequencies between dc and about 15 kHz 'chop' mode is used as trace speed across the screen (timebase speed) is relatively slow. About 15 kHz, 'alternate' mode is used when the timebase makes separate sweeps of the screen for each trace.

Two preamps are used, each having a bandwidth extending from dc to about 2000 kHz. The outputs of the channels are switched to the CRO input by an electronic changeover switch comprised of IC7c-d and IC8f, driven by an oscillator. Two oscillators are used, one for the chop mode, one for the alternate mode, as different switch speeds are necessary.

Setting CV1-CV4 is critical. Procedure is identical for both channels. Inject a 1 Vp-p 100 kHz squarewave into Input 1 and set SW2 to the 1/1 position. Setting of SW1 is unimportant. Set RV1 to maximum and RV2 to mid-position. Connect a CRO to the output of IC2 and adjust for the best squarewave response. (No overshoot and least rounding). Then move to IC3's output and adjust CV2 for best response. Repeat the procedure for the other channel.

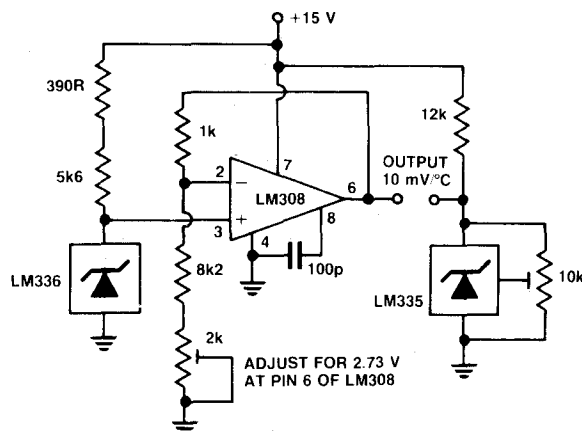
Logic analyser



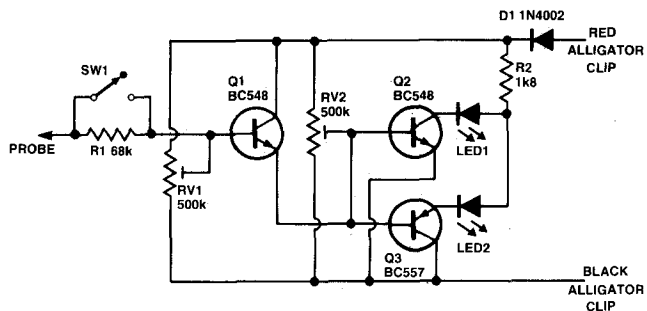
When testing logic circuits it is often necessary to know the simultaneous state of several nodes. To do it, you need a bunch of logic probes or a logic state analyser. The 'professional' tool is all-singing-and-dancing, and expensive. This circuit is a simpler implementation. Eight input bits are latched and displayed, controlled by the CONTROL INPUT from the circuit being analysed. It has three triggering modes: with SW1 at 1, it latches on a rising edge on the control input; with SW1 on 2, it latches on the falling edge control input; with SW1 on 3 it latches when PB2 is pressed. PB1 clears the latch.

Centigrade thermometer

This simple circuit can be used to measure temperature in Centigrade degrees and will read out directly on a standard digital multimeter. The LM336 is a precision 2.5 V voltage regulator, the LM335 a precision temperature sensor. The LM308 output provides a 'stiff' reference scaled up from absolute zero. The 2k trimpot is set to provide 2.73 V between pin 6 of the 308 and common. The 10k trimpot is set so that you get 2.982 V across the LM335 at 25°C. The LM335 can be used for contact temperature measurement.



Logic probe



This simple circuit was designed by Barry Drake of Scarborough Qld.

Connect the circuit to a power supply and set RV1 to about half way. Slowly turn RV2 so that the 'high' LED glows and then slightly turn it back until the 'low' LED glows. Now adjust

RV1 until both LEDs come on. If the probe goes high, Q1 and Q2 conduct and the 'high' LED goes on. If the probe goes low, Q3 conducts and the 'low' LED goes on.

SW1 and R1 were included for voltages greater than one volt.

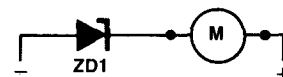
Range extender

Barry Bown of Lalor Victoria sent us this idea.

A problem with multimeters is that the 5, 10, and 50 volt range selection do not allow very accurate determination of voltages that lie just outside the range, like 12 volts.

He uses a 10 volt zener to convert the five volt range into a 10-15 volt range. In a similar way, almost any range can be obtained with the correct selection of zener values and meter range.

Meter Range	Zener Voltage	Extended Range
5 V	10 V	10-15 V
10 V	10 V	10-20 V
5 V	5 V	5-20 V
5 V	15 V	15-20 V



Electric floor heat earth leakage monitor

This circuit may look familiar to some since it's very similar to the warbling alarm in *Ideas for Experimenters*, ETI March 1980, wrote **Alec Phillips** of **Myrtleford Victoria**.

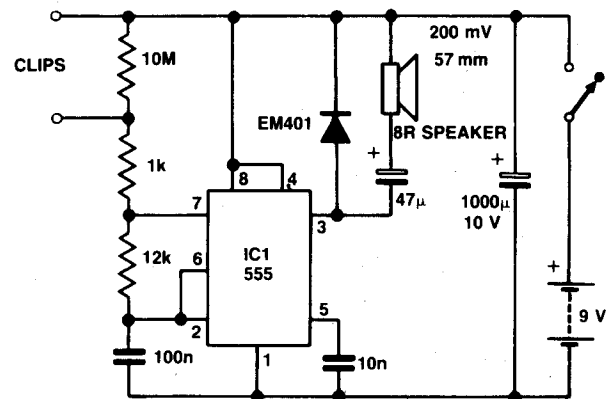
I made it in response to a request from an electrician friend of mine, who needed an audible monitor connected to electric floor heat coils while cement was being poured. One clip is connected to the outer earth casing and the other clip is connected to the centre element.

The circuit is basic and self explanatory. I mounted it in a Clipsal 265/3 PVC box, 102 mm x 102 mm x 70 mm, and used a 200 mW, 57 mm, 8R speaker

and a 9 V battery.

Normally the unit just ticks at about 1 kHz but if the heating coil is damaged by a shovel or a cement vibrator, the frequency suddenly increases to approximately 400 Hz, depending on the amount of resistance in the short circuit. Also, any small leakage of ten milliohms or less, will naturally increase the frequency of the output a small, but notable amount.

A special note: this will not do away with the final testing with a high voltage megger after the cement pour is completed, but it has proved very useful during a pour.



Compact UJT signal injector

Have you ever needed a compact signal injector for those little 'away from home' jobs? This simple circuit, designed by **N. J. Espie of Chermiside Qld** is powered by hearing aid batteries and will fit into a pen very nicely.

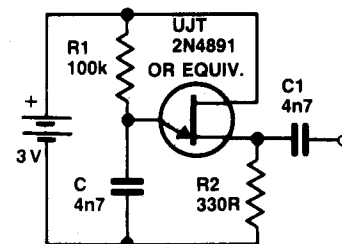
It can be used to test audio amplifiers, medium and short-wave receivers, and will even generate horizontal bars on a TV set if connected across the antenna terminals.

On powering up, capacitor C charges through resistor R1 until

the UJT becomes forward biased. The UJT will then provide a discharge path for C via its emitter and resistor R2, resulting in C discharging rapidly until the transistor is no longer forward biased. Once this occurs, capacitor C will again begin to charge up via R1 and so complete one cycle of oscillation.

The rapid discharging of the capacitor through the UJT provides a sharp pulse, rich in harmonics, suitable for outputting via a decoupling capacitor C1 to the probe tip.

For a stronger signal, earth the signal injector to the system under test using an alligator clip.



Polarity indicator

This polarity indicator, designed by **Malcolm Fields** of **Kangaroo Flat Victoria**, is for low voltage solid state work with 6, 9 or 12 V dc supplies.

The heart of the device is a simple Radio Shack tri-colour LED (276-035); very easy to see how it works, however, the sneaky bit is that with an ac current the red/green gives a yellow glow — a bonus which appealed to me. The other devices I had contemplated buying were either terribly expensive or unimaginative with two LEDs being used or great extensions I wouldn't dream of poking any instruments into.

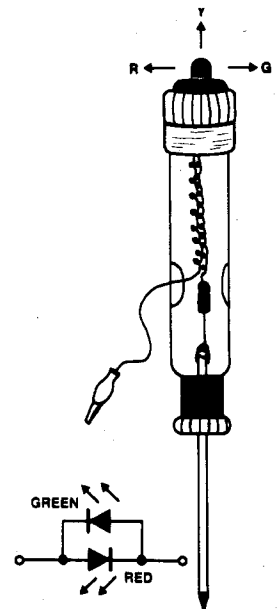
I wanted something rugged, comfortable, safe, attractive and useful. I decided to use an ordinary 240 V neon mains tester/screwdriver as the carrier/probe for the tester. Ellistronics has one which has an amber body and plastic sheaf along the screwdriver shaft, topped with a neat red plastic cap and contact.

I emptied out the neon tube and spring and drilled out the contact hole in the cap to take the body of the tri-colour LED (used a bit of epoxy). I used a 390R resistor as the brilliance it provides is adequate and should suit most applications.

I drilled a neat 3 mm hole in the middle of the optical viewing lens in the plastic body and

carried a light, black hook-up wire out to a black plastic mini-clip and into the short leg of the LED. Getting the internal contact from the LED through the resistor to the blade is tricky. I used a piece of copper tubing about 3 mm in diameter and 5 mm long and soldered (and crimped) the positive lead to it before forcing it on to the end of the shaft which protrudes about 4 mm into the neon compartment.

I used light wiring internally and sleeved all connections before giving the whole wiring about eight reverse twists which allowed me to screw the cap on nicely. The internal wiring has to be about 7-8 cm long to allow for twisting.



Logic probe/injector

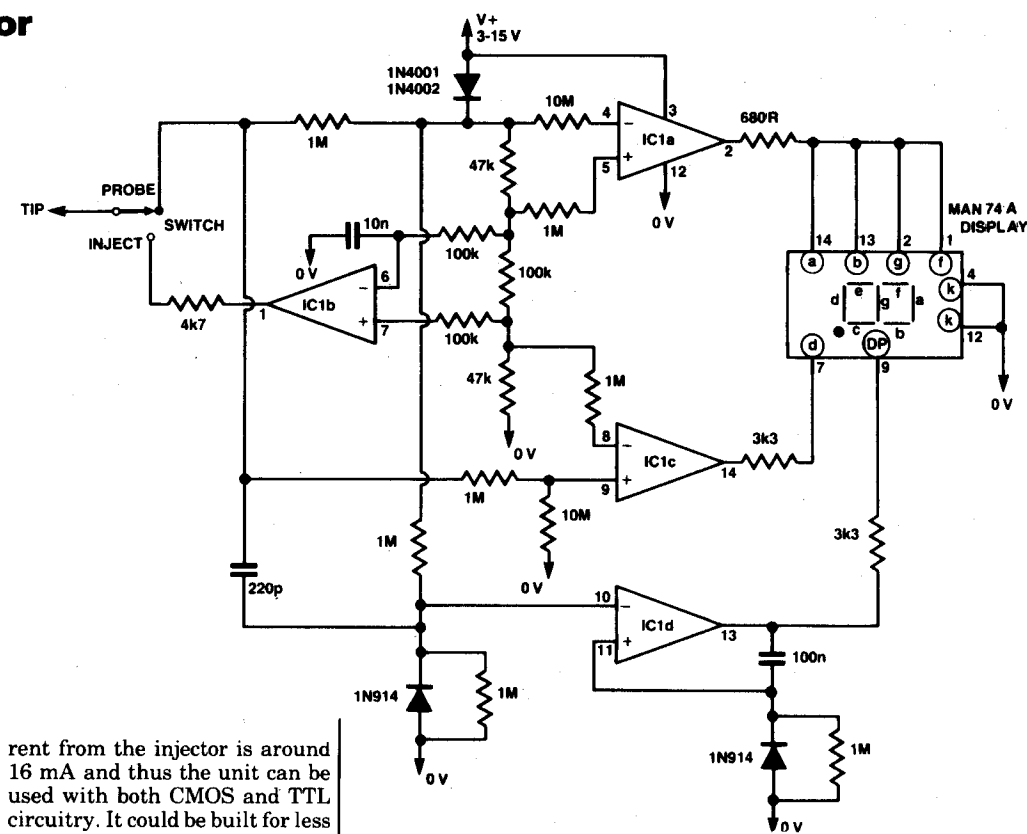
This digital logic probe uses a 7-segment LED display turned on its side to show a 1 or a 0 according to the state of the input, and to light the decimal point if the input is floating.

An LM339 quad comparator (IC1) is used to provide all functions. The display is a MAN74A, or similar. IC1a compares the input voltage with a reference voltage of half the supply voltage. If the input is a logic 0, then segments a-b-f-g of the display light, showing a zero on the right. If the input is a logic 1, then IC1c drives segment d of the display on, showing a 1 on the left.

With a floating input, a negative pulse will be stretched by IC1d, flashing the decimal point.

For an injector, IC1b is connected as an oscillator, producing square waves at its output. It oscillates at around 1 kHz. Rise and fall times of its output are around 100 ns. The switch is used to select the probe or injector function.

The supply voltage can range from 3 V to 15 V. Probe input current is around 2 μ A, sink cur-



rent from the injector is around 16 mA and thus the unit can be used with both CMOS and TTL circuitry. It could be built for less than \$10.

Positive/negative probe

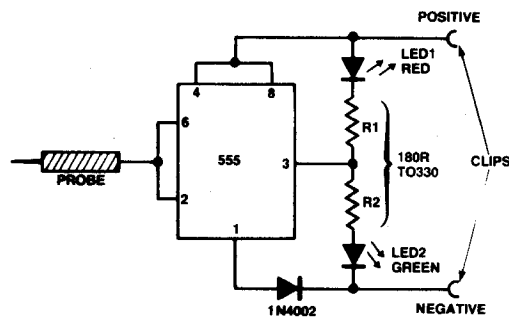
This circuit, which acts as a simple substitute for a voltmeter, was designed by David Pye of Happy Valley SA.

I've found in many cases that all I wanted to know was whether the reading was positive or negative. This is particularly useful in car or motorcycle electrical repairs and, as the unit can be made extremely small, it will fit in any tool kit.

It will fit in a small plastic pill container, operate on any voltage

between 5 V and 15 V and is quite cheap as it only requires a few components.

When the positive and negative clips are connected to the circuit both LEDs will light. Then when the probe touches a positive point the green LED is extinguished, leaving the red LED on, signifying positive. Touching the probe to a negative point extinguishes the red, leaving the green LED on. The 1N4002 is a protective diode for reverse polarity.



Simple negative/positive probe

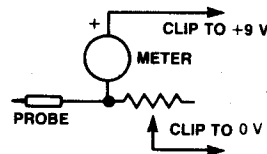
This very simple probe appears to be an obvious circuit, but it hasn't been done here before.

There are only two components in this circuit, a meter (650 ohms/250 μ A, full scale) and a variable resistor (50k).

To determine whether the reading is positive or negative

attach the two clips to the power supply of the circuit you want to test. Centre the meter by adjusting the variable resistor, then touch the part of the circuit you want to measure.

If the voltage is positive the meter will swing towards the positive side, and vice versa.



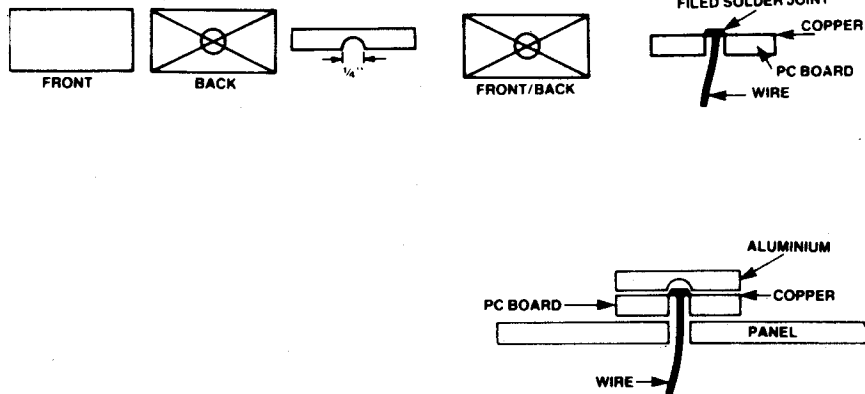
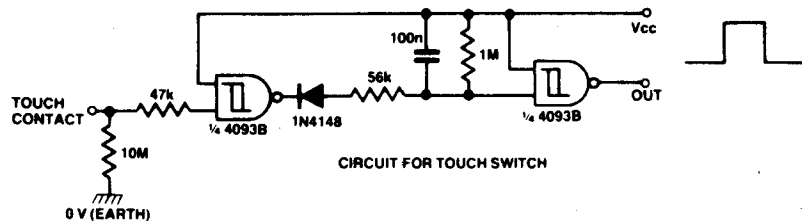
Making touch switches

One of the most difficult aspects of using touch switches in projects is the mechanical construction of the switch. This touch switch was designed by **Tim Wooler of Wahroonga NSW** to be used with the circuit found in the September 1981 ETI, page 51 Figure 5 (reproduced below). It is a method which is quick, easy and uses readily available parts.

The touch plate is constructed of aluminium sheet. A piece of aluminium is cut out to the size required, then in the centre back a small indent is made by drilling with a $\frac{1}{16}$ " bit half way through the aluminium, as shown.

If a matt finish is required the front of the aluminium may be sanded with successively finer grades of wet and dry paper. Then the aluminium is placed in Sodium Hydroxide solution for a few minutes to etch the surface. It is then washed clean, dried and sprayed with a coat of clear matt varnish. Drano, used for cleaning drains, is about 60% Sodium Hydroxide, and is ideal for etching the aluminium. Great care should be taken with the Sodium Hydroxide solution to keep it off the skin and clothes.

The amount of water required should be put in a plastic container then the Sodium Hydroxide added to make the solution. After the piece is sprayed with varnish lettering may be put on the front and another coat of varnish applied to hold it in place.



The next item required is a piece of blank pc board of the same size as the piece of aluminium. A $\frac{1}{16}$ " hole is drilled in the centre of the pc board. The wire for the switch is passed from the non-copper side through the hole and soldered. The joint is then filed down to make it as small as possible.

Now the switch is almost com-

plete. All that remains is to glue the aluminium piece to the pc board, the hole in the back of the aluminium covering the solder joint on the copper side of the pc board. Tarzans Grip worked well here. The switch is now complete. To mount the switch on a panel a hole is drilled for the wire and the pc board is glued to the panel, as shown.

Printed circuits designed simply

This idea, from **R.N. Sinclair of NSW**, is an old one but a good one that bears repeating.

Want to make prototype printed circuit boards quickly and easily? The following is a method I have used for many years now and provides reasonable accuracy of layout and speed of production where use of 'Bishop Graphics' is not warranted. The first thing to do is make a scale drawing of the desired layout on graph paper in pencil (0.1" grid is

ideal for integrated circuits), marking all points where holes are to be made.

Next clean your printed circuit board blank with a light abrasive and be sure it is clear of grease and dirt, then place a sheet of blue carbon paper face down on the copper board. Now place your layout drawing so that the back of the drawing is face up (therefore a reverse copy of the original) on the carbon paper and trace all the connecting lines, not forgetting to mark the points where holes are to be drilled.

At this point note that it is very important to keep the artwork rigid and in the same position in relation to the copper board, and it is much easier if a

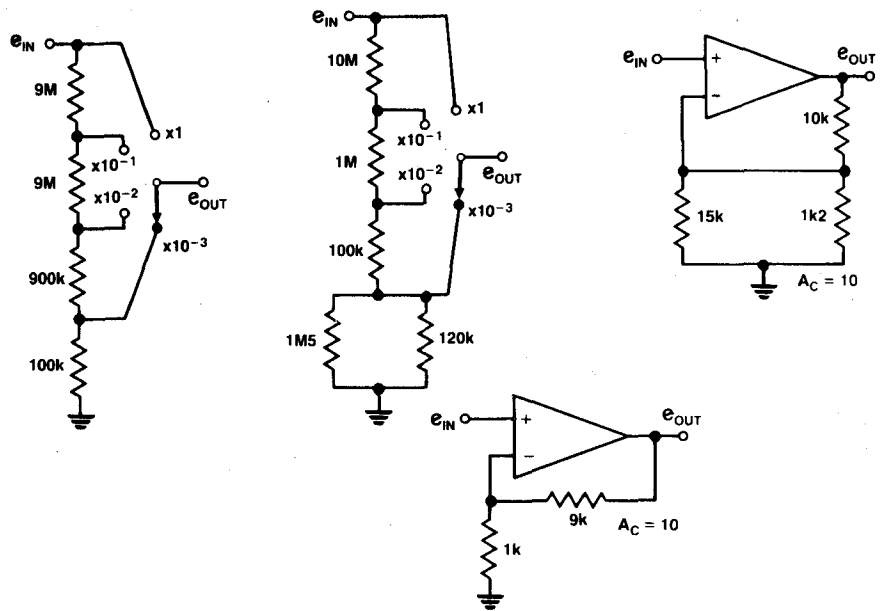
red pen is used for the tracing to avoid missing a section.

Now you have a carbon copy of the circuit layout on your board, and can simply use a clear or lightly coloured nail polish as a resist and etch in the normal manner. One the board is etched the holes must be drilled using the previously marked points, after which the nail polish can be removed with acetone (nail polish remover). Using the above method I can prepare a board ready for parts in 45 minutes, depending upon the complexity of the layout. It gives me a layout sketch for Bishop Graphics artwork and it provides a neat-looking circuit board as compared to Veroboard.

Voltage divider

Graham Taylor of Caulfield South, Victoria wanted to divide a voltage by a multiple of 10 and found the following circuit in application notes. This was all very well but then he couldn't buy a 900k resistor.

So then I started thinking about using different valued resistors. If you parallel 1.2 and 15 you get 1.1. Aha! So now I use dividers as shown. Now it's possible to go to your average hobby shop and buy 1% resistors off the shelf and not mess around with trying to make up 900k.

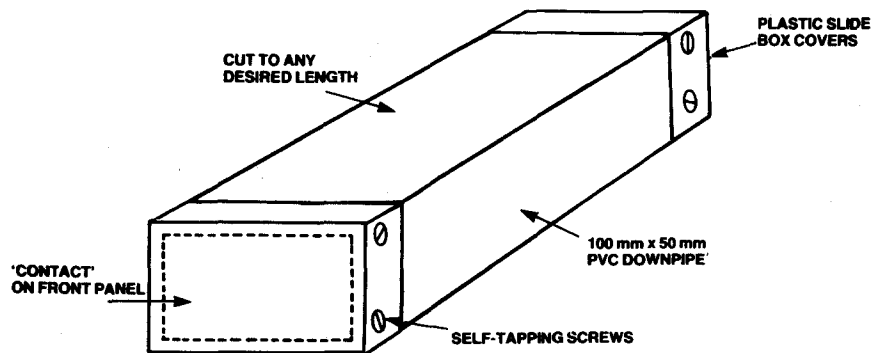


Box your doodads

If you ever need a small box to house your latest electronic doodad but don't have one on hand, a neat and inexpensive one can be made in about one minute from a short length of 100 mm x 50 mm PVC downpipe — according to Robert Jarvis of Epping, NSW, that is.

Such downpipe is often discarded on building sites, and is seamless and may be cut to any desired length. Two yellow plastic lids from Kodak slide boxes make neat-fitting end pieces, which can be secured with small self-tapping screws. The whole can be sprayed any desired colour, and the front lid dressed with a piece of 'Contact' adhesive or whatever if necessary.

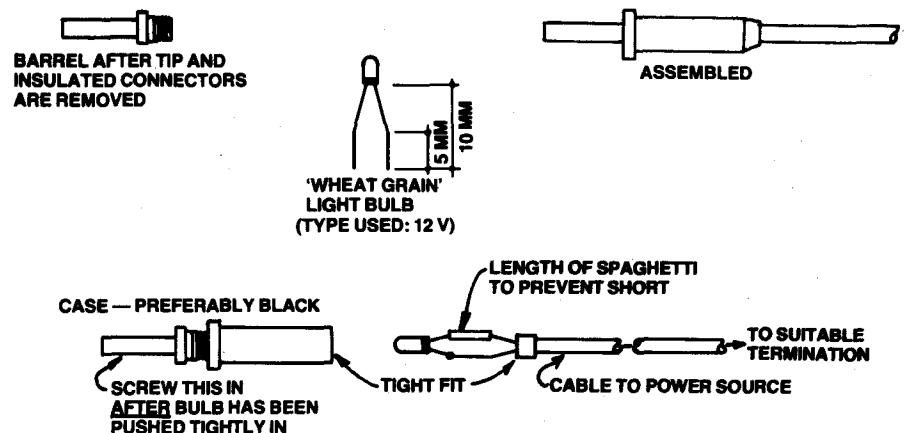
Care is needed when drilling the lids for pots, switches, etc, as the plastic is quite thin.



Pinpoint light

Ever needed a tiny light to illuminate a small corner? This device should find numerous applications around the home workshop, repair bench, etc. Construction is self-explanatory from the diagrams. Submitted by W. Brown of Dromana in Victoria.

- 1 x 3.5 mm plug with tip and hardware removed
- 1 x suitable voltage 'wheat grain' bulb
- 1 x suitable length of cable and power terminations



Drilling Scotchcal 8005 panels

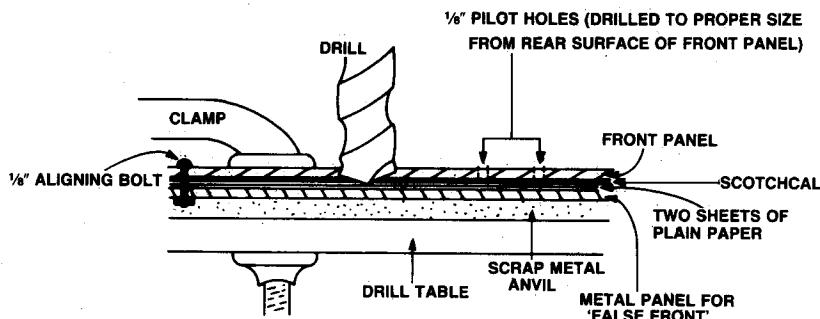
Scotchcal 8005 panels (black on Aluminium) are difficult to drill, especially in the case of large holes where tearing of the thin metal occurs. Burred and torn edges often result.

Ian Johnston of Mt Eliza, Victoria has come up with a solution.

Mount the panel material on the sheet metal panel surface, drill small pilot holes (say 1/8") wherever holes of any size are required. Mark on the back of the panel surface the finished hole size required.

Now lay the panel face down on a piece of sheet metal cut to the same size with two layers of plain paper between.

Keeping the panels exactly aligned, run the 1/8" drill through two holes (near to the edge) and bolt the two panels firmly together with 1/8" bolts. Now drill each hole to its correct size



(preferably using a drill-press) with the heel of a G-clamp holding the panels firmly down to the drilling table.

Place the clamp as close as possible to the drill. Move the panel, and re-clamp for each hole. Neat, clean holes will

result. It is best to drill into a piece of scrap metal plate placed under the work.

When drilling is finished the extra plate can be used for a 'false front', which many instrument panels require anyway.

LED bracket

An LED display with irregularities in the alignment and unevenness in the spacing between LEDs can make a project look very unprofessional.

David Samborsky of Bentleigh Vic. overcame this problem with a simple and effective method for mounting the LEDs in an array for display (typically for the ETI-438 audio level meter).

A piece of matrix board with standard spacing between the pre-punched holes was used. The pre-punched holes can be drilled slightly smaller than the diameter of the LEDs being used, so that the LEDs will fit securely into the holes drilled, without falling out.

The precise nature of the spacing between the pre-punched holes in the matrix board makes it an ideal mounting bracket for a display using an array of LEDs.

Matchbox cabinet for small components

Chris Nixon of Bentley WA has found a use for empty matchboxes.

A simple but effective method of storage for smaller components e.g. resistors, capacitors, transistors etc. is to glue matchboxes together to form a miniature cabinet. On the opening end of each matchbox write the values and abbreviated names of the components contained in the 'drawers'.

Winding metal-detector coils

Malcolm Young of Dunedin, NZ suggests this very novel way of producing large diameter metal detector coils.

Simply blow up a balloon to the right size, wind on the required number of turns and seal with five minute epoxy. Then pop the balloon!

Soldering CMOS chips safely

In articles describing an electronics project which uses CMOS chips there's usually a warning about the soldering of these devices. These warnings usually contain advice about heatsinking and earthing the barrel of the soldering iron etc.

Keith Jeeves of Kirrawee NSW describes a simple device which he uses for working with CMOS chips and he says this method has never let him down.

An IC test clip is a device with (usually) 16 pins arranged in a 'clothes peg' type clamp. It is intended to extend each of these pins of an IC to a tester, usually via a length of ribbon cable.

However, if all the tags at the top of the clip are connected together with short lengths of wire and a length of flexible lead is soldered to the arrangement with a crocodile clip attached to the free end, a foolproof soldering aid is the result.

In use, the crocodile clip is attached to the barrel of the soldering iron, the earth rail of the circuit board or any good earth.

The test clip is clamped over the IC while the chip is in its protective foam and used to transport the IC to the circuit board (use 1 — a handling device).

The clip is left in place during soldering and will shunt heat away from the chip (use 2 — a heatsink).

The clip will ensure that all the pins of the IC are at earth potential during soldering (use 3 — a static eliminator).

Uses for a drill vice

R. de Mouilpied of Coffs Harbour NSW has some useful hints for anyone who makes their own pc boards.

For enlarging holes in the pc board I use a small pin vice with three different size collets

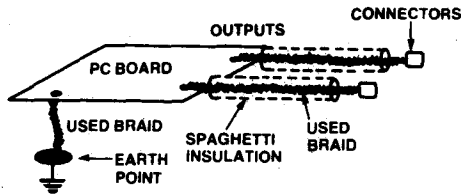
capable of holding small drills from 0.8 mm to 3.5 mm. This is also very handy for inserting pc board stakes, instead of using a pc board insertion tool.

The problem of sharpening small drills has been overcome by using an old electric can opener. I removed the can cutter section

and also the back plate covering the knife grinder. Then I put a switch on the side of the unit, connected the power and I had a small drill grinder.

I also use the pin vice for holding the drill while I am sharpening it, as I look through a head-type x10 magnifier.

Reuse spent solder braid



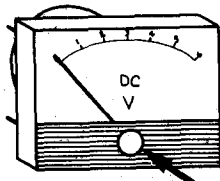
Don't throw away those used pieces of 'Solder Blotter' or other brands of desolder braid. **Peter Alter** of Glen Iris Victoria has found that it is an excellent, very low resistance conductor.

It can be used as an earth strap from circuit boards and connectors to the chassis or central earth point. Covered by spag-

hetti or heat shrink tubing, it makes an ideal low impedance lead for power supplies and amplifiers etc.

It has much lower resistance than hook-up wire, doesn't cost anything, and being rigid makes a good supporting strengthener for the pc board.

Novel position for pilot light



LED REPLACES THE ADJUSTING SCREW

When **V. Starr** of Higgins, ACT was finishing the ETI Dual Power Supply project he was trying to decide on the best place to put the pilot light

and came up with this idea.

The LED was placed into the hole used to adjust the needle movement, after removing the adjusting screw. In my case a 5 mm LED fitted almost perfectly.

The plastic case on most meter movements is easy to prise off. You can adjust the movement before replacing the plastic front and after fitting in the appropriate LED.

Take care in running wires or the appropriate dropping resistor from the LED.

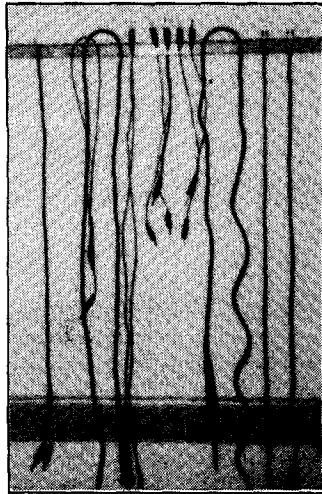
Leads and probes holder

If you want to have a tide electronic workshop this low cost lead holder should help.

H.F. Nissink of Launceston Tasmania sent in the idea which makes it easy to store test leads, BNC to BNC connectors and test probes etc.

Slotted cable is readily available through electrical suppliers at a fairly cheap rate. This cable ducting, cut to the required length and bolted to the wall, works well as a lead storage rack.

The slot size is ideal for electronic type leads. As well, the cable ducting may be cut along its length through the centre of the slots with the base of the U-shape bolted onto the wall as shown.



Circuit construction method

Here is an interesting method of building experimental and prototype circuits from **J. Drinda** of Villawood, NSW. It's quick, cheap and easy to troubleshoot.

Select a firm piece of cardboard or plastic, and glue all the components you require to it, with their connectors sticking up in the air. Then use thin wire to connect the various pins as required. The wire must be insulated, thin and flexible, and ideally, you should be able to solder it without having to strip it (ie, "Leumex" coil winding wire).

The connections should be made by a mixture of wrapping and soldering, i.e: wrap the wire around the pins as required, then when you have finished one node, go around and solder them all on. This ensures a good mechanical connection and provides a second check that you have everything correct.

Dewatering fluid test device

This test setup was constructed by **L. W. Brown** of Burwood Victoria to compare assorted cans of electrical (dewatering) spray.

The device is a 25 mm square of single-sided epoxy, glass fibre, copper laminate with a single, deep knife scratch across the middle.

A multimeter capable of measuring above one megohm was used to detect the presence of moisture.

A can of instant freeze (canned cold) is sprayed across the scratch to clean the board and then condense moisture from the atmosphere. Once the ice on the board has melted it will provide a leakage path of around one megohm.

Finally the de-watering fluid under test is used to remove this moisture; the results are alarming!

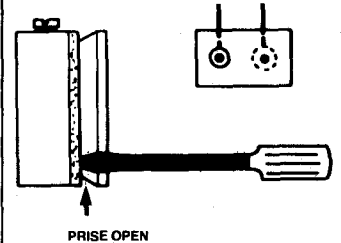
Transistor battery clip

Darryl Green of Elanora Qld. is another enterprising experimenter.

I was breadboarding a small circuit requiring an op amp and ± 9 V rails and found that I only had one 216 9 V battery clip.

But I did have an old 216 battery and discovered that by prising the metal case open I could remove the top plate with the clips mounted on it.

I then soldered wires on to the back of the plate, taking care not to melt the plastic. Hey presto! One battery clip.



Cassette tips

Eric Eulenstein of Albury NSW sent us some ideas on using cassettes.

The worst thing about using cassettes as a storage medium is that they take such an enormous amount of time to load and save. There are a number of techniques you can use to make things go a little faster though.

When loading a program from the cassette start, there is about ten seconds of dead time as the tape spools through the leader. Most of this wasted time can be eliminated by the physical removal of the leader. Of course, this can only be done with cassettes that have been assembled with screws.

Another technique that is very useful is to press RETURN before operating the RECORD key on the recorder. Remember there is a few seconds pause between the time the return key is operated and the time when the program issues forth.

WHERE THE ACTION IS!

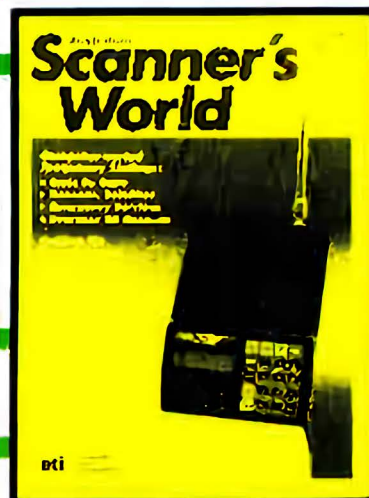


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